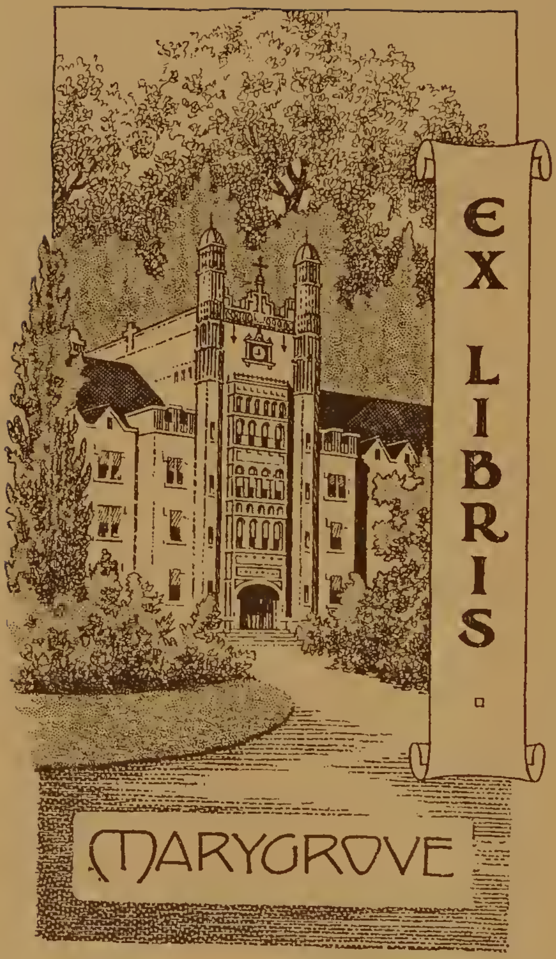
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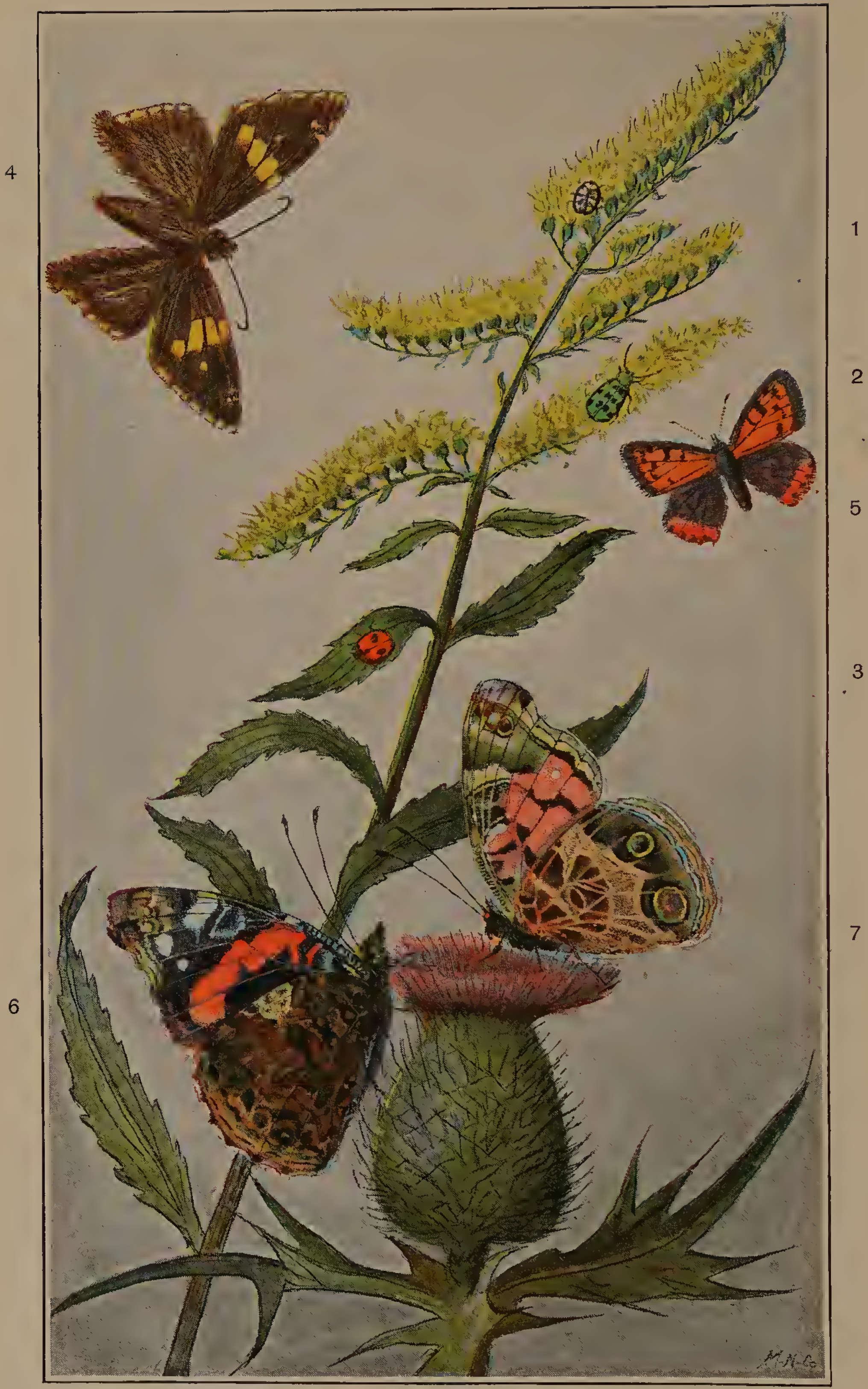
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A MANUAL

FOR THE

STUDY OF INSECTS

REVISED EDITION

BY

JOHN HENRY COMSTOCK
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AND

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Nineteenth Edition

ITHACA, NEW YORK
THE COMSTOCK PUBLISHING COMPANY
1930

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Revised Edition

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PREFACE TO ORIGINAL EDITION

For many years the most pressing demand of teachers and learners in entomology in this country has been for a handbook by means of which the names and relative affinities of insects may be determined in some such way as plants are classified by the aid of the well-known manuals of botany. But, as the science of entomology is still in its infancy, the preparation of such a handbook has been impossible. Excellent treatises on particular groups of insects have been published; but no general work including analytical keys to all the orders and families has appeared. It is to meet this need that this work has been prepared.

The reader must not expect, however, to find that degree of completeness in this work which exists in the manuals of flowering plants. The number of species of insects is so great that a work including adequate descriptions of all those occurring in our fauna would rival in size one of the larger encyclopædias. It is obvious that such a work is not what is needed by the teachers and students in our schools, even if it were possible to prepare it. An elementary work on systematic entomology will always of necessity be restricted to a discussion of the characteristics of the orders and families, and descriptions of a few species as illustrations. Complete synopses of species will be appropriate only in works treating of limited groups. It is believed, therefore, that it would not be wise to materially change the scope of the present work even if it were possible to describe all of our species.

Although much pains has been taken to render easy the classification of specimens, an effort has been made to give the mere determination of the names of insects a very subordinate place. The groups of insects have been fully characterized, so that their relative affinities may be learned; and much space has been given to accounts of the habits and transformations of the forms described. As the needs of agricultural students have been kept constantly in view, those species that are of economic importance have been described as fully as practicable, and particular attention has been given to descriptions of the methods of destroying those that are noxious, or of preventing their ravages.

An effort has been made to simplify the study of insects as much as possible without sacrificing accuracy in the descriptions. Only such morphological terms have been used as were necessary to accomplish the object of the book in a satisfactory manner. And so far as possible a uniform nomenclature has been used for all orders of insects. The fact that writers on each order of insects have a peculiar nomenclature has been a serious obstacle to the progress of entomology; this is especially true as regards the nomenclature of the wing-veins. It has been necessary for the student in passing from the study of one order of insects to that of another to learn a new set of terms; and in many cases writers on a single family have a peculiar nomenclature.

The present writer has endeavored to remove this obstacle by making a serious study of the homologies of the wing-veins, and by applying the same term throughout the work to homologous veins. The result is that the student is required to learn only one set of terms; and in applying these terms there will be brought to his attention in a forcible manner the peculiar modifications of structure characteristic of each order of insects. Heretofore, with a different nomenclature for the wing-veins of each order such a comparative study of the various methods of specialization has been beyond the reach of any but the most advanced scholars.

The principal features of the method of notation of wing-veins proposed by Josef Redtenbacher has been adopted. But as the writer's views regarding the structure of the wings of primitive insects are very different from those of Redtenbacher, the nomenclature proposed in this book is to a great extent original. The chief point of difference arises from the belief by the present writer that veins IV and VI do not exist in the Lepidoptera, Diptera, and Hymenoptera; and that, in those orders where they do exist, they are secondary developments. The reasons for this belief are set forth at length in my essay on Evolution and Taxonomy.

In this essay there was proposed a new classification of the Lepidoptera, which was the result of an effort to work out the phylogeny of the divisions of this order. This classification has been further elaborated in the present work. In the other orders but few changes have been made from the more generally accepted classifications. It is more than probable however, that when the taxonomic principles upon which this classification of the Lepidoptera is based are applied to the classification of the other orders radical changes will be found to be necessary.

A serious obstacle to the popularization of Natural History is the technical names that it is necessary to use. In order to reduce this difficulty to a minimum the pronunciation of all of the Latin terms used has been indicated, by dividing each into syllables and marking the accented syllable. In doing this the well-established rules for the division of Latin words into syllables have been followed. It seems necessary to state this fact in order to account for differences which exist between the pronunciations given here and some of those in certain large dictionaries recently published in this country.

Nearly all of the wood-cuts have been engraved from nature by the Junior Author. As the skill which she has attained in this art has been acquired during the progress of the work on this book, some of the earlier-made illustrations do not fairly represent her present standing as an engraver. But it does not seem worth while to delay the appearance of the book in order to re-engrave these figures; especially as it is believed that they will not be found lacking in scientific accuracy. The generous appreciation which the best engravers have shown towards the greater part of the work leads us to hope that it will be welcomed as an important addition to entomological illustrations.

Although the chief work of the Junior Author has been with the pencil and graver, many parts of the text are from her pen. But in justice to her it should be said that the plan of the book was changed after she had finished her writing. It was intended at first to make the book of a much more elementary nature than it is in its final form. It has seemed best, however, to leave these parts as written in order that the work may be of interest to a wider range of readers than it would be were it restricted to a uniform style of treatment.

The figures illustrating the venation of the wings of insects have been drawn with great care under the writer's direction by Mr. E. P. Felt and Mr. R. H. Pettit. About one half of those in the chapter on Lepidoptera were drawn by Mr. Felt; the others in this chapter and those in the chapters on Diptera and Hymenoptera were drawn by Mr. Pettit.

I wish also to acknowledge the help of my Assistant Mr. A. D. MacGillivray, to whom I am indebted for much aid in bibliographical researches and in many other ways; also, that of Dr. A. C. White of the Cornell University Library, who has generously given much time to determining the etymologies of many of the more obscure words the pronunciations of which are indicated in the text.

To the authorities of Cornell University the authors of this book are under deep obligation for aid and encouragement. The preparation of the work would not have been possible but for the liberal grants which they have made for the purchase of specimens and books.

JOHN HENRY COMSTOCK

ENTOMOLOGICAL LABORATORY,
CORNELL UNIVERSITY,
December, 1894

FOREWORD

The Manual for the Study of Insects, published in 1895, was written to meet the needs of teachers of Entomology when that science was in its infancy as an academic study. It was well received and accomplished its purpose, and there has been a continuous call for it since; it is now in its eighteenth edition. Owing to the rapid development of the science it became necessary to revise the book and I began this before my retirement in 1914. However, so great has been the growth of Entomology that this intended revision of the Manual resulted in a new textbook, An Introduction to Entomology.

I still had it in mind to revise the Manual, making it more elementary, when failing health prevented. It is with relief and confidence that I pass this task on to Professor Glenn W. Herrick, whom I trained when he was an undergraduate and who has now many years of successful teaching and careful research to his credit.

John Henry Comstock

April 5, 1929.

INTRODUCTION

Some time during the year 1895, a package containing the first volumes of "A Manual for the Study of Insects" fresh from the press, came to the Insectary at Cornell University where the writer lived and worked as a student in entomology. Professor Mark Vernon Slingerland and the writer rushed with feverish haste to open the box in order to see and handle as quickly as possible, this wonderful book, the publication of which we had awaited with such great anticipation and interest. The event, because of its inspirational value, was almost as significant in the life of the writer as it was, for other reasons, in that of the author of the book; and now after thirty-odd years it becomes a peculiar pleasure to have the opportunity of revising that first Manual of Professor Comstock's.

The aim of the revision has been to keep the Manual in form and arrangement practically as it was first written. The attempt has been made, of course, to bring the subject-matter down to date, to simplify it and to condense it somewhat in order to bring it within the horizon of the beginning student. The more advanced student in entomology has been adequately cared for by Professor Comstock's much more extended work, "An Introduction to Entomology," and by other works of somewhat similar character.

The writer acknowledges with gratitude, the interest and hearty aid of his colleagues, notably that of Dr. O. A. Johannsen who compiled the simplified table of the Diptera and who read the manuscript on that order; that of Dr. W. T. M. Forbes who formulated the shorter table of the Lepidoptera and also read and criticised the text treating of this order; that of Dr. J. C. Bradley with the Hymenoptera; and of Dr. J. G. Needham from whose papers and works on the aquatic forms the writer has drawn freely.

Some of the old figures of the Manual have been omitted, notably several of those illustrating wing-venation. The need of these is not so great at this time for the Comstock-Needham system of naming the wing-veins of insects is now thoroughly established and familiar to students and teachers of entomology. Many new figures have been added. The writer is indebted to Doubleday, Page and Company for permission to use figures 11, 21, 23, 24, 25, 27, 28, 29, and 35, from the "Spider Book" by J. H. Comstock, to H. Holt and Company, for figures 270, 302, and 564, from the "Manual of Injurious Insects," by Glenn W. Herrick, to MacMillan Company for figures 13, 30, and 510, from Herrick's "Insects Injurious to the Household" and to Dr. Grace H. Griswold for figure 598a.

Glenn W. Herrick

Ithaca, N.Y.
Dec. 2, 1929.

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The internal anatomy of a cockroach.

CHAPTER I

INSECTS AND THEIR NEAR RELATIVES

PHYLUM ARTHROPODA

The Arthropods

Zoologists recognize at least twelve great groups or phyla of animals, — Protozoa (one-celled animals), Porifera (sponges), Cœlenterata (hydras, sea-anemones), Platyhelminthes (flatworms), Nemathelminthes (roundworms), Trochelminthes (rotifers), Molluscoidea (lampshells), Annulata (earthworms, et al.), Echinodermata (starfish), Mollusca (clams, oysters), Arthropoda (spiders, insects), and Chordata (fishes, birds, mammals). In organization and development the phylum Arthropoda, stands high in the series as indicated in the foregoing linear arrangement. Indeed, the arthropods stand next to the fishes, reptiles, birds and mammals, the highest forms in the animal kingdom.

If an insect, a spider, a scorpion, a centipede, or a lobster be examined, the body will be found to be composed of a series of more or less similar rings or segments joined together; and some of these segments will be found to bear segmented legs (Fig. 1). All the animals possessing these characteristics are classed together as the phylum *Arthropoda*.

A similar segmented form of the body is found among worms; but these are distinguished from the arthropods by the absence of legs. It should be remembered that many animals commonly called worms, as the tomato-worm, apple-worm, etc., are not true worms, but are the larvæ of insects (Fig. 2). The earthworm is the most familiar example of a true worm.

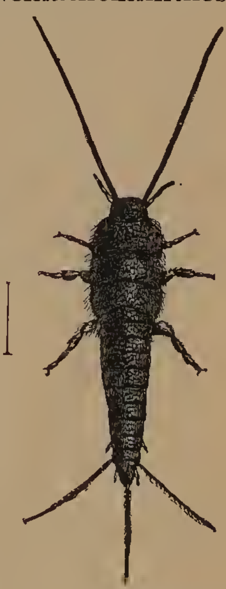

FIG. 1. — An insect showing segmented form of body.

In the case of certain arthropods the distinctive characteristics of the phylum are not evident from a cursory examination. This may be due to a very generalized condition; but in most instances it is due to a second-

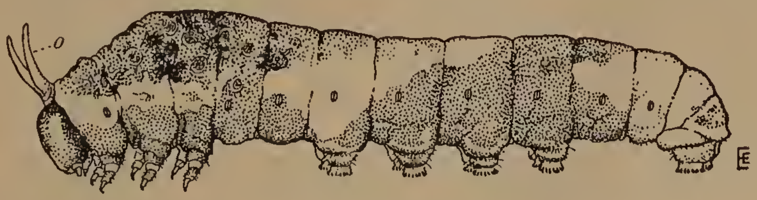

FIG. 2. — Larva of butterfly, *Papilio thoas*.

ary modification of form, the result of adaptation to special modes of life. Thus the segmentation of the body may be obscured, as in spiders and in mites (Fig. 3); or the jointed appendages may be absent, as in the larvæ of flies, of bees, and of many other insects. In all of these cases, however, a careful study of the structure of the animal, or of its complete life-history, or of other animals that are evidently closely allied to it removes any doubt regarding its being an arthropod.

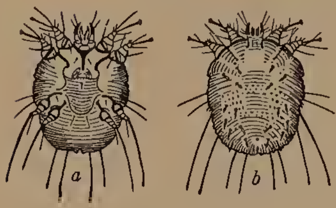

FIG. 3. — An Itch-mite: *a*, from below; *b*, from above.

The phylum Arthropoda is the largest of the phyla of the animal kingdom, including many more known species than all the other phyla taken together. This vast assemblage of animals includes forms differing widely in structure, all agreeing, however, in the possession of the essential characteristics of the Arthropoda. Several distinct types of arthropods are recognized; and those of each type are grouped together as a class.

The number of distinct classes that should be recognized, and the relation of these classes to each other are matters regarding which there are still differences of opinion; we must have much more knowledge than we now possess before we can speak with any degree of certainty regarding them. Some authorities recognize thirteen classes of arthropods; but since most of them contain forms which are rarely seen by most students only the more common representatives will be discussed. These are distributed among the following classes: Crustacea, Arachnida, Diplopoda, Chilopoda, and Hexapoda.

CLASS **CRUSTACEA**

The Crustaceans

The members of this class are aquatic arthropods, which breathe by true gills. They have two pairs of antennæ and at least five pairs of legs. The position of the openings of the reproductive organs varies greatly; but as a rule they are situated far forward.

The most familiar examples of the Crustācea are the cray-fishes, the lobsters, the shrimps, and the crabs. Cray-fishes (Fig. 4) abound in our brooks, and are often improperly called crabs. The lobsters, the shrimps, and the true crabs live in salt water.

The Crustacea are distinguished from nearly all other arthropods by their mode of respiration, being the only ones that breathe by true gills. Many insects live in water and are furnished with gill-like organs; but these are either tracheal gills or blood-

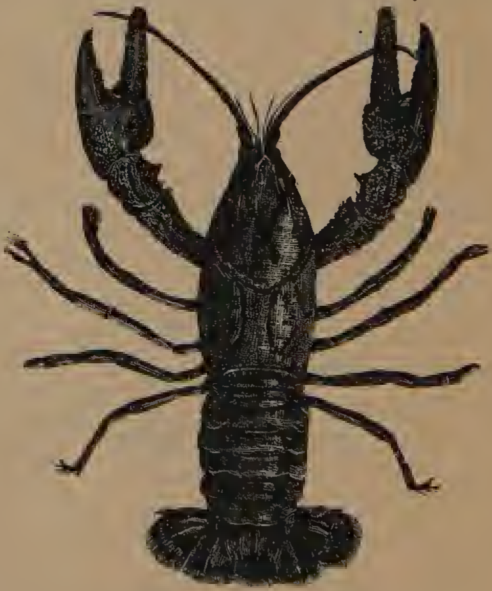

FIG. 4. — A Cray-fish.

gills, organs which differ essentially in structure from true gills, as described later. The Crustacea also differ from other Arthropoda in having two pairs of antennæ. Rudiments of two pairs of antennæ have been observed in the embryos of many other arthropods; but in these cases one or the other of the two pairs of antennæ fails to develop.

The examples of crustaceans named above are the more conspicuous members of the class; but many other smaller forms abound both in the sea and in fresh water. Some of the more minute fresh-water forms are almost sure to occur in any fresh-water aquarium. In Figure (5) are represented three of these enlarged. The minute crustaceans form an important element in the food of fishes.

Some crustaceans live in damp places on land, and are often found by collectors of insects; those most often observed are the sow-bugs (Oniscoida), which frequently occur about water-soaked wood. Figure (6) represents one of these.

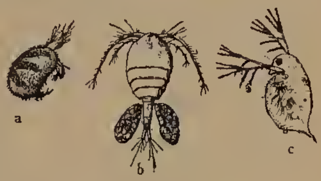

FIG. 5. — Crustacea: *a*, *Cypris*; *b*, *Cyclops*; *c*, *Daphnia*.

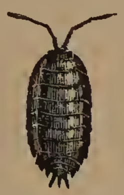

FIG. 6. — A Sow-bug.

CLASS **ARACHNIDA**

Scorpions, Harvestmen, Spiders, Mites, and others

The members of this class are air-breathing arthropods, in which the head and thorax are usually grown together, forming a cephalothorax, which has four pairs of legs, and which apparently has no antennæ. The reproductive organs open near the base of the abdomen.

The Arăchnida abound wherever insects occur, and are often mistaken for insects. But they can be easily distinguished by the characters given above, even in those cases where an exception occurs to some one of them. The more important of the exceptions are the following: in one order, the Solpugida, the head is distinct from the thorax; as a rule the young of mites have only six legs, but a fourth pair is added during growth; and in the gall-mites there are only four legs.

The Arachnida are air-breathing; but it is believed that they have been evolved from aquatic progenitors. Two forms of respiratory organs exist in this class: first, book-lungs; and second, tubular tracheæ. Some members of it possess only one of these types; but the greater number of spiders possess both.

The Arachnida lack true jaws. Therefore they do not masticate their prey and swallow the parts. They crush their victims and suck out the juices. The first pair of organs on the cephalothorax constitutes the principal crushing organs. They are modified antennæ and are known as cheliceræ. Other appendages, however, may aid in the crushing process. Each one of the second pair of appendages just behind the cheliceræ is leglike in form. These are known as the pedipalps. Following the pedipalps are the four pairs of legs. Thus the cephalothorax of the Arachnida bears six pairs of appendages. The Arachnida have only simple eyes.

The more familiar forms of this class are the scorpions, harvestmen, spiders, and mites.

Order PEDIPALPIDA

The Whip-scorpions

These strange creatures are found in our country only in the extreme southern part for they are tropical animals; but they are distributed from the Atlantic to the Pacific. In their general form they bear some resemblance to the scorpions; but they can be easily distinguished from the scorpions by the form of the first pair of legs and of the post-abdomen.

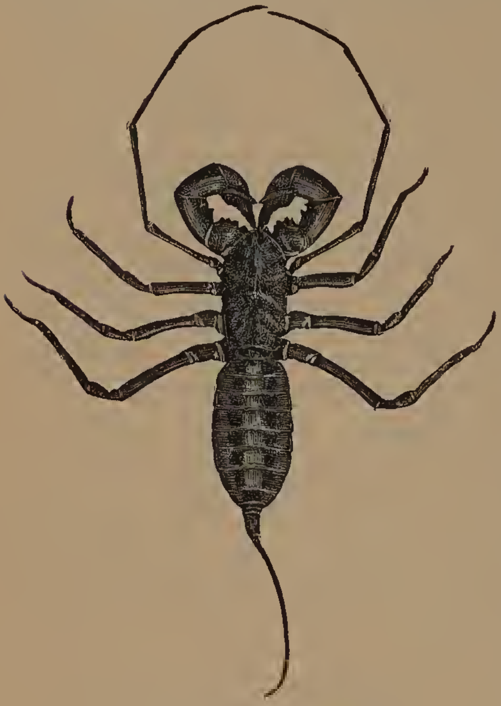
Fig. 7. — *Mastigoproctus giganteus.*

The front legs are greatly elongated (Fig. 7) and have the tarsi broken up into many small slender segments giving this part of the leg a whip-lash-like appearance. In addition, the members of one family have the caudal end of the abdomen furnished with a slender, many-segmented appendage resembling a tail. These forms are known as the "tailed whip-scorpions" (Fig. 7). There is, however, but one species of this family in the United States, the giant tailed whip-scorpion, *Mastigoprŏctus gigantēus*, which, when full-grown, attains a length of from four to five inches (Fig. 7). Its bite is said to be poisonous but direct, authentic evidence of its supposed venomous quality is lacking. This species burrows in sand under logs or other objects lying on the ground; it doubtless feeds on any insects that it can capture.

There is another family of these creatures known as the tailless whip-scorpions because the individuals lack the tail-like appendage of the abdomen so conspicuous in the tailed species. The front legs, however, of these tailless forms are even more whip-lash-like in appearance than those of the giant whip-scorpion but the body is relatively shorter and broader. There are only four species of this family found in this country and these are in the extreme South. They are smaller than the giant whip-scorpion.

There is a third family represented by a single species in the United States *Trithy̆reus pentapĕltis*, which is less than one-half an inch in length. It lives in the desert regions of Southern California.

Order SCORPIONIDA

The Scorpions

The scorpions (Fig.. 8), have the body divided into a compact, unsegmented cephalothorax, and a long, segmented abdomen. The abdomen is divided into two portions: a broad pre-abdomen, consisting of seven segments; and a slenderer tail-like division, the post-abdomen, consisting of five segments. At the end of the post-abdomen there is a large poison-sting, which appears like a segment. The cheliceræ and the pedipalpi are provided with pincers. The pedipalpi resemble in a striking manner the great claws of lobsters. The cephalothorax bears from three to six pairs of eyes. Scorpions breathe by means of lung sacs, of which there are four pairs, opening on the lower side of the third to the sixth abdominal segments.

Full-grown scorpions possess a pair of comb-like organs on the lower side of the second abdominal segment. The function of these organs may be tactile.

The sexes of scorpions differ in that the male has broader pincers and a longer post-abdomen. Scorpions do not lay eggs, the young being developed within the mother. After the birth of the young, the mother apparently shows great regard for them, carrying them about with her for some time, attached by their pincers to all portions of her body.

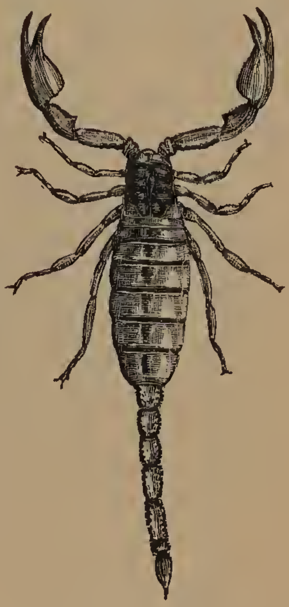
FIG. 8. — A Scorpion.

Scorpions live in warm countries. They are common in the southern portion of the United States, but are not found in the North. They are nocturnal, remaining concealed during the day, but leaving their hiding-places at dusk. When they run the post-abdomen of some species is bent upwards over the back. They feed upon spiders and large insects, which they seize with the large pincers of their palpi, and sting to death with their caudal poison sting.

The sting of a scorpion rarely if ever proves fatal to a grown man, although the larger species, which occur in the Tropics, produce serious effects by their stings.

Order PSEUDOSCORPIONIDA

The Pseudoscorpions

The pseudoscorpions are small arachnids which resemble scorpions in the form of their pedipalps and of their body, except that the hind part of the abdomen is not narrow, as is the post-abdomen of scorpions, and they have no caudal sting. The abdomen is broad, flat, and thin and only one or two pairs of eyes are present on the cephalothorax.

The pedipalps are enormously developed and are chelate, resembling those of the scorpions (Fig. 9). The pseudoscorpions are especially interesting because they possess silk glands in the cephalothorax which open near the tip end of each chelicera. The silk which they spin is used for making a web or cocoon in which the pseudoscorpion can retreat during the moulting period and during the winter.

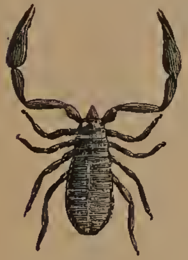
FIG. 9. — A Pseudoscorpion.

There are many species of pseudoscorpions in the United States, found in the North as well as in the South. They live under stones, beneath the bark of trees, in moss, under leaves on the ground, in the nests of bees, of ants, and of termites and in households where they are often found between the leaves of books. It is believed that they live on mites and minute insects. They are often found attached to flies and beetles and according to one observer they sometimes kill the flies and eat them.

Order PHALANGIDA

The Harvestmen, or Daddy-long-legs

The harvestmen are very common in most parts of the United States. They are well known to children in this country under the name daddy-long-legs, but as this name is also sometimes applied to crane-flies, harvestmen is preferable. In some sections of the country the harvestmen are known as grandfather graybeards.

Most harvestmen can be recognized by their very long and slender legs (Fig. 10) although some species have comparatively short ones. The cephalothorax is indistinctly if at all segmented. The abdomen is short, broad, consists of nine segments, and is without a tail-like appendage; it is broadly joined to the cephalothorax.

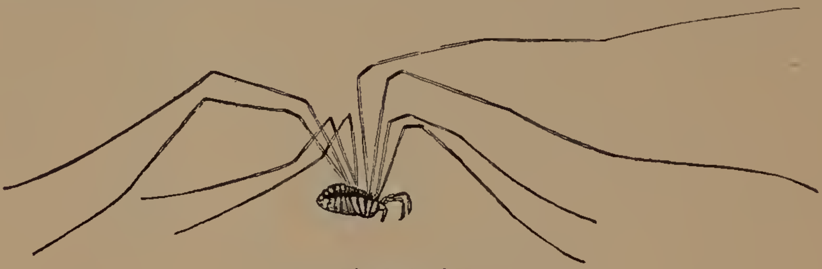

Fig. 10 — The Striped Harvestman.

The eyes of the harvestmen are two in number, and are situated on a prominent tubercle near the middle of the cephalothorax. The cheliceræ are pincer-like. Their pedipalpi are four-jointed, and are small compared with the pedipalpi of the preceding orders; they resemble in form the palpi of insects. The members of this order breathe by tracheæ, which open by a single pair of spiracles, on the lower side of the body at the junction of the cephalothorax and abdomen.

There seems to be some uncertainty regarding the food of harvestmen. Some writers say they live on dead insects while others aver that they feed on live aphids and other small insects. It seems clear that they also suck the juices of fruits and soft vegetables.

In the North most harvestmen die in the autumn after they have deposited eggs under stones, or in crevices or in the ground. These eggs do not hatch until the following spring. In the South more of the adults hibernate under rubbish during the winter.

No silk glands have been found in the harvestmen and they do not make webs like the spiders.

Order ARANEIDA

The Spiders

The spiders differ from other Arachnida in having the abdomen unsegmented and joined to the cephalothorax by a short, narrow stalk.

The cephalothorax is also unsegmented; and the abdomen bears at its end organs for spinning silk (Fig. 11).

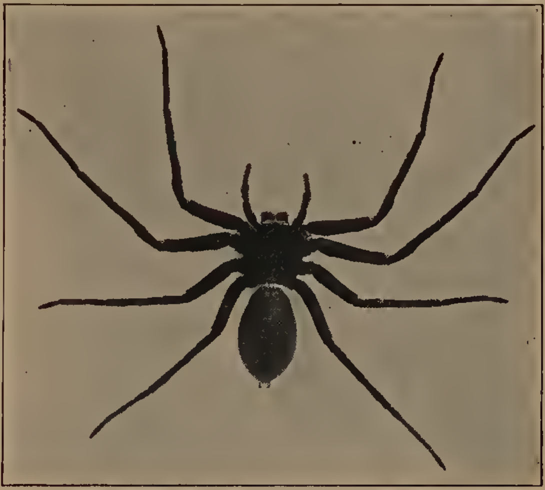

Fig. 11. — The banana spider showing division of body into cephalothorax and abdomen.

The cheliceræ (Fig. 12, *md*) consist of two segments, a strong basal one and a claw-shaped terminal one, at the tip of which a poison gland opens (Fig. 13). It is by means of these organs that spiders kill their prey. The pedipalpi are leg-like in form, but differ greatly according to sex. In the female the last segment of the pedipalpus resembles a foot of the spider, and is usually armed with a well-developed curved claw. But in the male the corresponding segment is more or less enlarged, and very complicated in structure (Fig. 14). The greater number of spiders have four pairs of eyes, but there may be only one, two, or three pairs; and certain cave spiders are blind. Spiders breathe by means of lung-sacs, of which there are one or two pairs; and some have tracheæ also. The lung-sacs open on the lower side of the abdomen near its base, and between them is the opening of the reproductive organs. The tracheæ open through a single spiracle near the hind end of the body, usually just in front of the spinning organs.

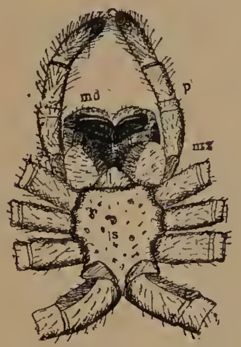

Fig. 12. — Lower side of cephalothorax of a spider; *md*, chelicera; *mx*, maxilla; *p*, palpus; *l*, lower lip; *s*, sternum.

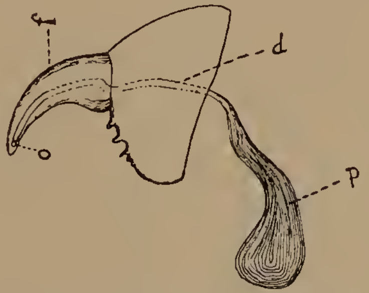

Fig. 13. — Chelicera of a spider: *p*, poison gland; *d*, duct; *o*, opening at tip of fang; *f*, fang.

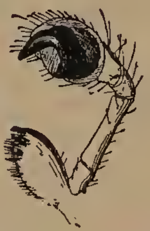

Fig. 14. — Maxilla and palpus of male house-spider.

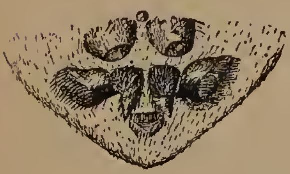

Fig. 15. — End of abdomen of spider, showing six spinnerets spread apart; in front of these is the spiracle, and behind them the opening of the alimentary canal.

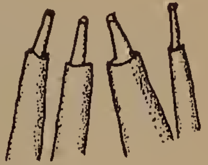

Fig. 16. — A group of spinning tubes, greatly enlarged.

The spinning organs, which are situated near the end of the abdomen, consist of one or two or three pairs of *spinnerets*. These appendages (Fig. 15) are more or less finger-like in form, and sometimes jointed. Upon the end of each spinneret there are many small tubes, the *spinning tubes*, from which the silk is spun (Fig. 16). Some spiders have one hundred or more of these spinning-tubes on each spinneret. The silk is in a fluid state while it is within the body, but it hardens as soon as it comes in contact with the air.

Ordinarily the tips of the spinnerets are brought close together, so that all the minute threads that emerge from the numerous spinning-tubes unite to form a single thread. This, however, may be so delicate as to be invisible, except in a favorable light. Sometimes a spider will spread its spinnerets apart, and thus spin a broad ribbon-like band. We have observed a spider seize a large grasshopper which was entangled in its web, and, rolling it over two or three times, completely envelop it in a sheet of silk spun from its spread-apart spinnerets.

In the construction of their webs the orb-weaving spiders make use of two kinds of silk. One of these is dry and inelastic; the other, viscid and elastic. This fact can be easily seen by examining an orb web. If the spiral line which forms the greater part of the web be touched, it will adhere to the finger, and will stretch, when the finger is withdrawn, to several times the original length. But if one of the radiating lines or a portion of the outer framework be touched, it will neither adhere to the finger nor be stretched. If the spiral line be examined with a lens, it will be found to bear numerous bead-like masses of viscid matter (Fig. 17); this explains its adhesiveness.

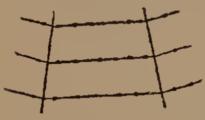

Fig. 17. — Viscid silk from an orb web.

It is supposed that the two kinds of silk are spun from different spinnerets. When this silk is first spun the viscid matter forms a continuous layer of liquid on the outside of it. But very soon this layer breaks up into the bead-like masses — in a way similar to that in which the moisture on a clothes-line on a foggy day collects into drops.

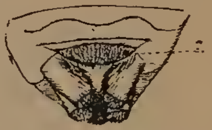

Fig. 18. — End of abdomen showing cribellum, *c*.

Spiders of the two families *Dictynidæ and Uloboridæ* have spinning organs differing from those of all other spiders. They have in front of the usual spinnerets an additional organ, which is named the *cribellum* (Fig. 18). This bears spinning-tubes like the other spinnerets, but these tubes are much finer. These spiders have also on the metatarsus of the hind legs one or two rows of curved spines: this organ is the *calamistrum* (Fig. 19). By means of the calamistrum these spiders comb from the cribellum a band of loose threads, which forms a part of their webs.

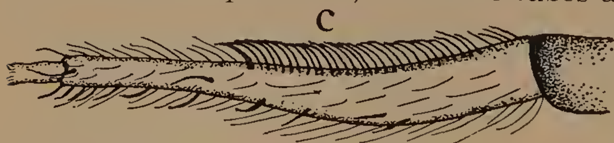

Fig. 19. — Metatarsus of hind leg of spider showing calamistrum, *c*.

Spiders make use of silk in the construction of their webs or snares, in the building of tubes or tents within which they live, in the formation of egg-sacs, and in locomotion.

Figure 20 represents the large egg-sac of one of the orb weavers. This is made in the autumn, and contains at that season a large number of eggs — five hundred or more. These eggs hatch early in the winter; but no spiders emerge from the egg-sac until the following spring. If egg-sacs of this kind be opened at different times during the winter, the spiders will be found to increase in size but diminish in number as the season advances. In fact, a strange tragedy goes on within these egg-sacs: the stronger spiders calmly devour their weaker brothers, and in the spring those which survive emerge sufficiently nourished to fight their battles in the outside world.

The egg-sacs of the different species of spiders vary greatly in form. In some, as in that figured below, the outer covering is very dense, while in others the outer part consists of thin flossy silk (Fig. 21). One of the most common kinds is very flat, silvery in color, and is firmly attached to stones lying upon the ground (Fig. 22).

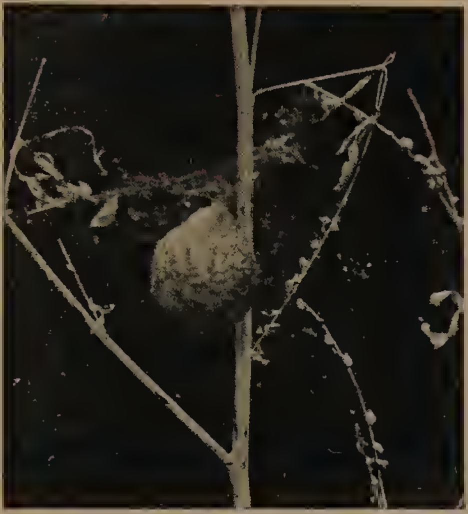
FIG. 20. — Egg-sac of *Argiope*.

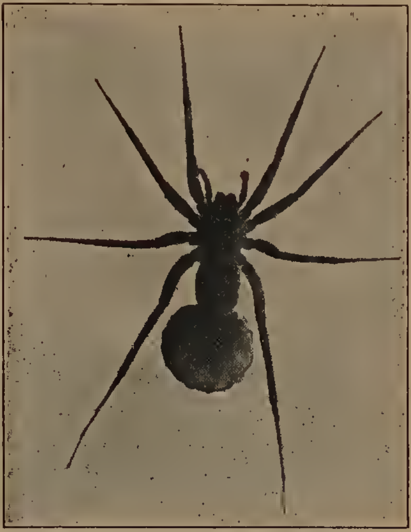
FIG. 21. — Lycosa with thin egg-sac.

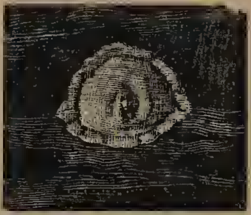
FIG. 22. — Egg-sac on under side of a stone.

Every one knows that a spider wishing to descend to some place beneath it simply fastens a line to the object which it is upon and then drops boldly off, regulating the rate of its descent by spinning the line rapidly or slowly; when the spider wishes to return, it has only to climb up the same line.

Frequently spiders pass from point to point in a horizontal direction by means of silken bridges. These are formed in this way: the spider spins out a thread, which is carried off by a current in the air. After a time the thread strikes some object and adheres to it; then the spider pulls the line tight, and fastens it where it is standing. It then has a bridge, along which it can easily run.

But more remarkable than either of these uses of silk for locomotion is the fact that many spiders are able to travel long distances, hundreds of miles, through the air by means of these silken threads —

"sailing mid the golden air
In skiffs of yielding gossamere." — (*Hogg.*)

The aeronautic spiders, or flying spiders, as they are more commonly called, are frequently very abundant, especially on warm autumn days. At such times innumerable threads can be seen streaming from fences, from bushes, and the tips of stalks of grass, or floating through the air. The flying spider climbs to some elevated point, which may be merely the tip of a stalk of grass, and then, standing on the tips of its feet, lifts its body as high as it can, and spins out a thread of silk. This thread is carried up and away by a current of air. When the thread is long enough the force of the air current on it is sufficient to buoy the spider up. It then lets go its hold with its feet and sails away. These spiders travel long distances over the sea far from land in this manner.

Representatives of thirty families of spiders are found in the United States but only a few common forms can be discussed here, those which best illustrate the habits of these most interesting animals. The spiders will, however, well repay one for further study of them. With the exception of the hour-glass spider, common in the South and the tarantulas found in the Southwest, spiders are harmless creatures and as safe to observe and handle as beetles or ants.

Family Aviculariidæ

The Tarantulas and the Trap-door Spiders

Those who live in the warmer parts of our country know well the large spiders commonly called tarantulas. These are the giants among spiders, some of them being the largest known; but some species of this family are not very large. They are dark-colored, hairy spiders, and can be distinguished from the other families mentioned here by the fact that the chelicerae work up and down instead of sidewise.

The members of this family have various habits. Some live in the cracks of trees or under stones or rubbish on the ground or sometimes in a simple cell dug in the earth and lined with a slight web of silk. Others dig definite tunnels in the ground, line them with silk and in many cases close the opening with a door or lid. Others spin webs resembling those of the grass-spiders known as the funnel-web weavers.

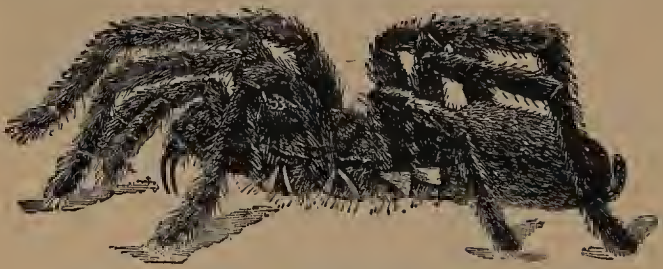

Fig. 23. — A Tarantula, *Eurypelma hentzi.*

One of the best known of the tarantulas is *Eurўpelma hĕntzi.* This species occurs in the southern and southwestern states, and is one of the largest of our spiders (Fig. 23). Several closely allied species are found in California.

But the members of this family that have attracted most attention on account of their habits are the trap-door spiders. These dig a tube in the ground, as do many other members of this family; but this tube is lined with a denser layer of silk, and is provided with a hinged lid, which fits the opening of the tube with wonderful accuracy (Fig. 24). The spider hides in this nest when not seeking its prey. Some species take the precaution to build a branch to their nest, and to provide this branch with a door. As this door forms a part of one side of the main tube, it is not likely to be observed by any creature which may find its way past the first door of the nest.

Several species of trap-door spiders occur in the southern and southwestern states. The habits of many of these spiders are not yet known. They should be studied much more.

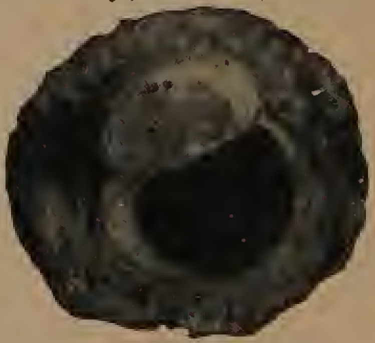

Fig. 24. — Entrance to tunnel of trap-door spider. (From the Spider Book, Doubleday, Page and Co.)

Family AGELENIDÆ

The Funnel-web Spiders

Even the most careful observers seldom realize what an immense number of spider-webs are spun upon the grass in the fields. But occasionally these webs are made visible in the early morning by the dew which has condensed upon them. At such times we may see the grass covered by an almost continuous carpet of silk.

The greater number of the webs seen at such times are of the form which we term funnel-webs. They consist of a concave sheet of silk, usually with a funnel-shaped tube at one side, and numerous lines extending in all directions to the supporting spears of grass (Fig. 25). The tube serves as a hiding-place for the owner of the web; from this retreat the spider runs out on the upper surface of the web to seize any insect that alights upon it. The tube opens below, near the roots of the grass; so that the spider can escape from the web if a too formidable insect comes upon it.

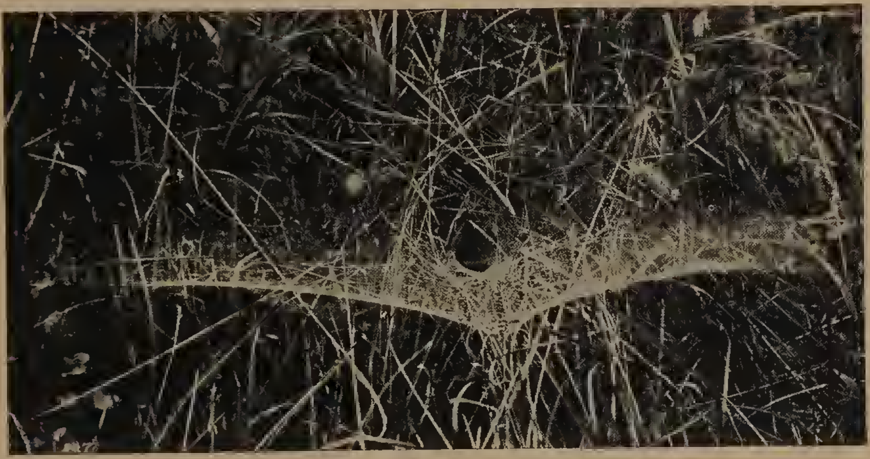

FIG. 25. — Web of *Agelena.*

The funnel-web spiders are long-legged usually brownish individuals with the hind pair of spinnerets very long while the feet have three claws. The eyes of these spiders are eight in number and arranged in two rows.

Probably the most common spider in our fauna is the grass-spider or funnel-web weaver (*Agelēna nævia*) whose webs are found everywhere during the summer spun on the grass. The webs are most conspicuous in the early morning when the dew has condensed on them.

To this family also belongs the remarkable aquatic spider of Europe (*Argyronēta aquătica*) which lives among plants at the bottom of clear quiet ponds. It breathes air adhering to its body which it brings from above the surface of the water.

Family DICTYNIDÆ

The Hackled-band Spiders with irregular webs

Certain spiders are remarkable for using two kinds of silk in the formation of their webs. Thus, as explained later, the orbweavers build the framework of their orbs of dry and inelastic threads, and attach to this framework a thread which is sticky and elastic; while most spiders which make irregular webs use only one kind of silk. There are, however, certain species of irregular web-weavers which use two kinds of silk. One of them is a plain thread like that spun by other spiders, and the other is a peculiar ribbon-like thread or band with curled threads running through it. This ribbon-like band with its curled threads we have called the hackled-band.

The hackled-band weavers represent two families, one of which makes irregular webs; the other, those which are of definite form. The first of these is the Dictynidæ.

The hackled-band is made in the same way by both families. It is composed of silk spun probably partly from certain of the spinnerets and partly from the *cribĕllum* (page 8); and is combed into its peculiar form by means of the comb of stiff hairs, the *calamĭstrum*, which is borne by the metatarsus of the hind legs (see page 8). In making the hackled-band the spider turns one of its hind legs under the abdomen so that the calamistrum is just under the spinnerets and makes a rapid combing motion. By the rapid combing motions of the hind legs the calamistrum finally combs out from the spinning-tubes a flat-thread and at the same time tangles through it some curled threads; but it is difficult to determine just how the hackled-bands are given their characteristic form and the whole process is not well understood.

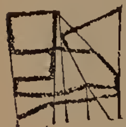

Fig. 26. — Curled thread of a Dictynid, enlarged.

This band of tangled or curled threads is easily seen in the webs of these spiders, being wider than the ordinary threads and white in color. In old webs it becomes conspicuous by the large amount of dust which it collects. Figure 26 shows the appearance of this band when magnified, and the way in which it is attached to the plain threads.

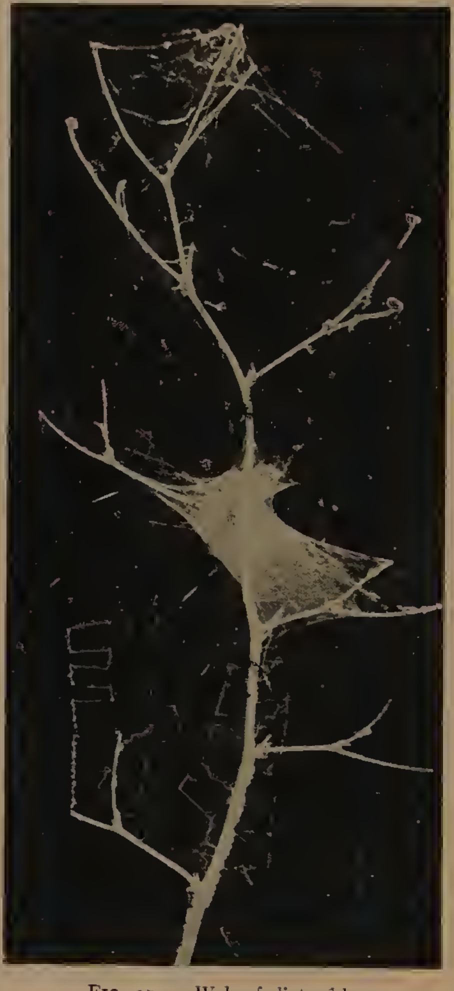

Fig. 27. — Web of dictynid.

Our more common dictynids make webs of various shapes, on fences, under stones, in holes in rotten logs, and on plants. These webs are especially common among the flowers of golden-rod and other plants having clusters of small flowers (Fig. 27), and exhibit a slight degree of regularity.

Family ULOBORIDÆ

The Hackled-band Spiders with regular webs

We have already described the ribbon-like threads, or hackled-bands of the dictynids (p. 12), and the curious organs called cribellum and calamistrum, by which these curled threads are made (p. 8). Similar organs and a similar habit are possessed by the spiders of the family Uloboridæ. These spiders, however, make webs which are regular in form. There are only two genera belonging to this family in the United States; but as the webs made by these are very different, we will describe both.

The triangle spider, *Hyptīotes cavātus.* — This spider is common all over New England and the Middle States, and has been found as far to the Southwest as Texas. Its web is most often found stretched between the twigs of a dead branch of pine or spruce. At first sight this web appears like a fragment of an orb web (Fig. 28); but a little study will show that it is complete. The accompanying figure, from a photograph of a web of the triangle spider spun between two dead twigs of a pine tree, illustrates the form of the web. It consists of four plain lines corresponding to the radiating lines of an orb web, and a series of double cross lines, which are spun by the cribellum and calamistrum. From the point where the radiating lines meet a strong line extends to one of the supporting twigs. Near this twig the spider rests, pulling the web tight so that there is some loose line between its legs, as shown in the enlarged figure. When an insect becomes entangled in one of the cross lines, the spider suddenly lets go the loose line so that the whole web springs forward, and the insect is entangled in other cross threads. The spider then draws the web tight and snaps it again. This may be repeated several times before the spider goes out upon the web after its prey.

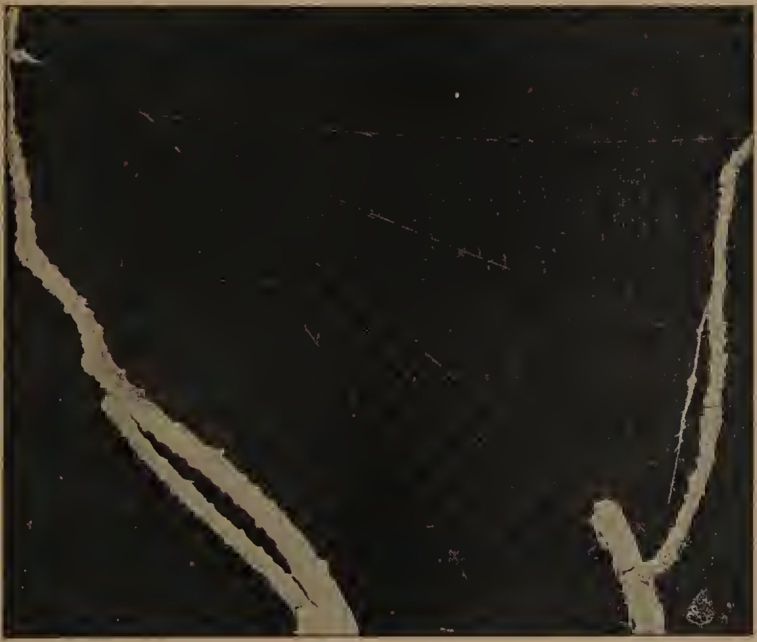

FIG. 28. — Web of triangle spider.

Uloborus. — The spiders of this genus make round webs which resemble at first sight those of the orb weavers; but they differ from the ordinary orb webs in that the spiral thread is made of the hackled-band silk. These webs are nearly horizontal, and are usually made between stones or in low bushes. The spiders of this genus are not common, but they are widely distributed.

Family Theridiidæ

The Comb-footed Weavers

Many are the kinds of webs spun by different spiders. Some of them, as the orb webs and the funnel-webs, delight us with their wonderful regularity of form; while others appear to be a mere shapeless maze of threads. Such are the structures whose presence in the corners of our rooms torment thrifty housewives, and which are disrespectfully termed cobwebs. The most common spinner of cobwebs is the abundant house-spider, *Therĭdion tepidariōrum*, which spins its irregular webs composed of threads extending in all directions with no apparent regularity, in any convenient corner. The spider, which hangs in its web with its back downwards, will serve well as a representative of this family.

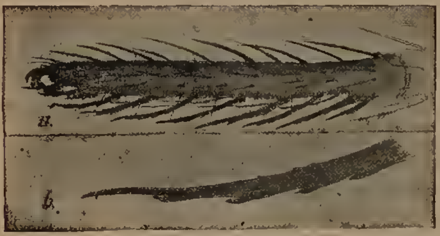

Fig. 29. — Comb of Theridion; *b*, a tooth of comb, enlarged. (From the Spider Book, Doubleday, Page and Company.)

These spiders have eight eyes and three tarsal claws. In addition, they have on the tarsus of the fourth pair of legs a distinct comb consisting of a row of strong, curved, and toothed setæ (Fig. 29). As the presence of this tarsal comb distinguishes these spiders from all others, they may well be called the comb-footed spiders. The comb is used for flinging silk, often in a quite liquid state, over the entangled prey. Although the house-spiders are the most familiar members of this family, a large number of species spin their webs in the fields on bushes. These webs usually consist of a flat or curved sheet, under which the spider hangs back downward. This sheet is supported by threads running in all directions to the neighboring objects. Frequently there is a large number of these supporting threads above the web, which serve the additional purpose of impeding the flight of insects, and causing them to fall into the web, where they are caught. A few species which do not live in webs and spin very little, are found under stones, or in the moss and leaves, and run with great rapidity.

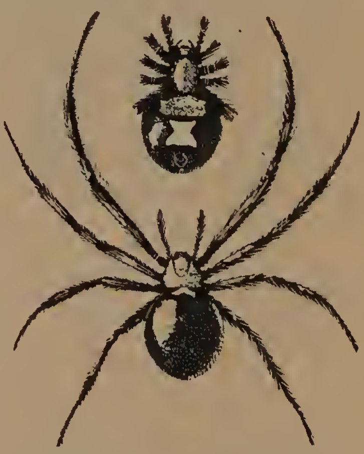

Fig. 30. — The hour-glass spider. Ventral side above to show the red marking

One spider of this family, *Latrodĕctus măctans*, commonly known as the "black widow" or hour-glass spider is, outside of the tarantulas, the one poisonous spider in this country. It is a coal-black spider with a red marking in the form of an hour-glass on the underside of the abdomen (Fig. 30). The female is about one-half an inch in length. This spider is common all over the southern states and occurs as far north as Pennsylvania and Ohio, at least.

Family ARGIOPIDÆ

The Orb Weavers

Few if any of the structures built by lower animals are more wonderful than the webs of orb-weaving spiders, but these beautiful objects are so common that they are often considered hardly worthy of notice. If they occurred only in some remote corner of the earth, every one would read of them with interest.

The webs of the different species of orb weavers differ in the details of their structure, but the general plan is quite similar. There is first a framework of supporting lines. The outer part of this framework is irregular, depending upon the position of the objects to which the web is attached; but the more central part is very regular, and consists of a number of lines radiating from the center of the web (Fig. 31). All of these supporting lines are dry and inelastic. But there is spun upon the radiating lines in a very regular manner a thread which is sticky and elastic (Fig. 17, p. 8). Usually this sticky thread is fastened to the radiating lines so as to form a spiral, but a few species make webs in which this thread is looped back and forth.

Many of the orb weavers strengthen their webs by spinning a zigzag ribbon across the center. This ribbon is made by spreading the spinnerets apart so that the minute threads from the spinning-tubes do not unite to make a single thread, as is usually the case.

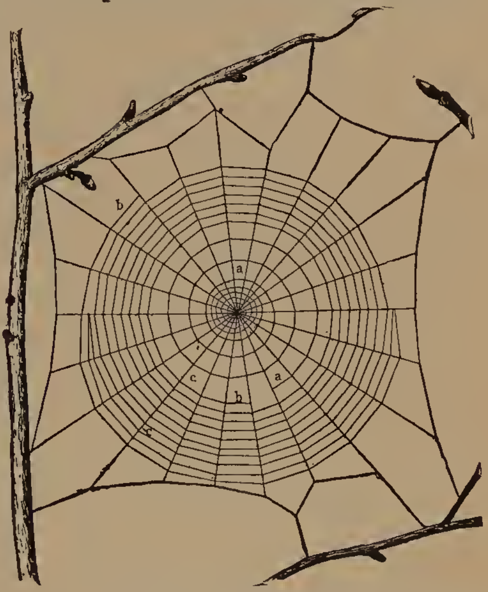

FIG. 31. — Partially completed web of Argiope.

Some of the orb weavers live in their webs hanging head downward, usually near the center of the web; others have a retreat near one edge of the web, in which they wait for their prey. While resting in these retreats they keep hold of some of the lines leading from the web, so that they can instantly detect any jar caused by an entrapped insect.

When an insect in its flight touches one of the turns of the sticky line, the line sticks to it; but it stretches so as to allow the insect to become entangled in other turns of the line. If it were not for this elasticity of the sticky line, most insects could readily tear themselves away before the spider had time to reach them.

In making its web an orb weaver first spins a number of lines extending irregularly in various directions about the place where its orb is to be. This is the outer supporting framework. Often the first line spun is a bridge between two quite distant points. This is done as described on p. 9. Having a bridge across the place where the web is to be, it is an easy matter for the spider to stretch its other lines where it wishes them. In doing this it fastens a thread to one point, and then walks along to some other point, spinning the thread as it goes, and holding it clear of the object on which it is walking by means of one of its hind legs. When the second point is reached the thread is pulled tight and fastened in place.

After making the outer framework the radiating lines are formed. A line is stretched across the space so as to pass through the point which is to be the center of the orb. In doing this the spider may start on one side, and be forced to walk in a very roundabout way on the outer framework to the opposite side. It carefully holds the new line up behind it as it goes along, so that it shall not become entangled with the lines on which it walks; one or both hind feet serve as hands in these spinning operations. The spider then goes to the point where the centre of the orb is to be, and fastening another line there, it walks back to the outer framework, and attaches this line an inch or two from the first. In this way all of the radiating lines are drawn. The next step is to stay these radii by a spiral line which is begun at the center, and attached to each radius as it crosses it. The turns of this spiral are as far apart as the spider can conveniently reach, except at the center of the web. All of the threads spun up to this stage in the construction of the web are dry and inelastic. The spider now proceeds to stretch upon this framework a sticky and elastic line, which is the most important part of the web, the other lines being merely a framework to support it. In spinning the sticky line the spider begins at the outer edge of the orb, and passing around it fastens this line to each radius as it goes. Thus a second spiral is made. The turns of this spiral are placed quite close together, and the first spiral, which is merely a temporary support, is destroyed as the second spiral progresses. Figure 31 represents a web in which the second spiral is made over the outer half of the radii. In this figure, *aa* represents the temporary stay-line; *bb* the sticky spiral; and *cc* the fragments of the first spiral hanging from the radii.

The orb weavers are three-clawed, eight-eyed, sedentary spiders. The tarsi are more or less clothed with hairs; but they lack the comb characteristic of the Theridiidæ. They are fairly common, many of our large garden spiders being common representatives.

Family THOMISIDÆ

The Crab Spiders

There are certain spiders which are called crab spiders, on account of the short and broad form of the body, and the curious fact that they can walk more readily sidewise or backward than forward.

These spiders spin no webs, but lie in wait for their prey. They live chiefly on plants and fences, and in the winter hide in cracks and under stones and bark. Most of the species are marked with gray and brown, like the bark upon which they live. Some species conceal themselves in flowers, where they lie in wait for their prey. These are brightly colored, like the flowers they inhabit; so that insects visiting flowers may alight within reach of a spider before seeing it.

In this family the legs are turned outward and forward more than downward; so that the body is carried close to the ground. The legs of the second pair are as long as or longer than those of the fourth pair. The eyes are small, nearly equal in size, and arranged in two rows.

One of the best-known members of this family is the female of *Misūmena vātia*, which is frequently found in flowers (Fig. 32). She is remarkable for the change in the color of her body which takes place when she migrates from one flower to another of different color. In the spring the female frequents the white flowers of trillium, fleabane, and other plants. She then has a ground color of white. Later in the season when she migrates to golden-rod or other yellow flower her body becomes yellow in color.

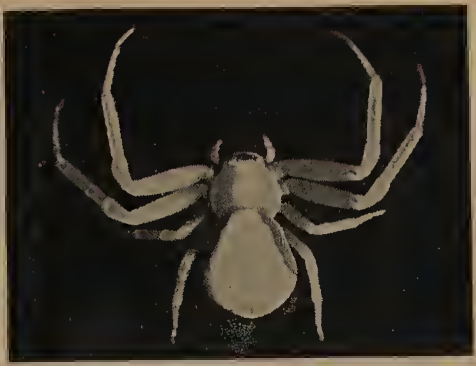

FIG. 32. — *Misumena vatia.*

Family LYCOSIDÆ

The Running Spiders

Every collector of insects who has searched for specimens under stones and logs is familiar with the large, dark-colored, hairy spiders often found in these places. These spiders frequently attract especial attention by dragging after them a large gray ball (Fig. 33); this is the egg-sac, which the female carries about with her attached to her spinnerets. These spiders run swiftly; and as they depend on the use of their legs for the capture of their prey, they are well termed running spiders.

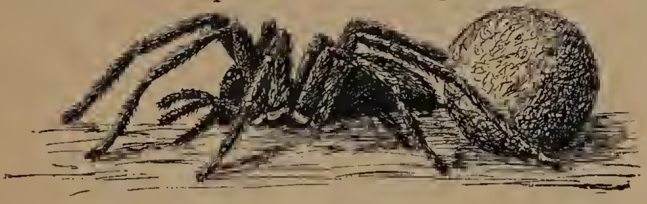

FIG. 33. — *Lycosa* and egg-sac.

These spiders resemble in general appearance and in habits the tarantulas of the South and the West. But none of our species attain the great size of some of the tarantulas, and in the running spiders the claw of the cheliceræ moves horizontally instead of vertically.

In this family the body is hairy and usually much longer than broad. The eyes differ markedly in size, and are arranged in three rows. The larger eyes are not in the front row. The legs are rather long and quite stout.

Like the tarantulas, some of the running spiders build tubular nests in the ground, which they line with silk. Sometimes the entrance to these nests is concealed by small sticks and leaves, and sometimes the spider builds a regular turret over the entrance of its tube (Fig. 34). These nests are used mostly as retreats. A few species spin webs.

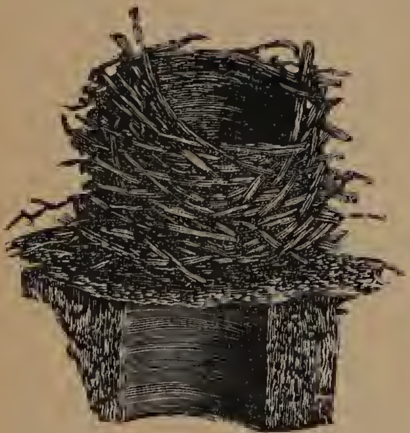

FIG. 34. — Entrance to nest of turret spider, *Lycosa*. (After Marx.)

The larger members of our common species belong to the genus *Lycosa*. These drag after them their egg-sacs as described above; and when the young hatch they climb on their mother's back, and are carried about for a time. Whether the mother provides nourishment or not for the young during this period has not been definitely determined.

Family ATTIDÆ

The Jumping Spiders

The jumping spiders are of medium size, with a short body and short stout legs (Fig. 35). They are common on plants, logs, fences, and the sides of buildings. They are very apt to attract attention by their peculiar appearance; their short stout legs, bright colors, conspicuous eyes, and quick, jumping movements being very different from those of ordinary spiders.

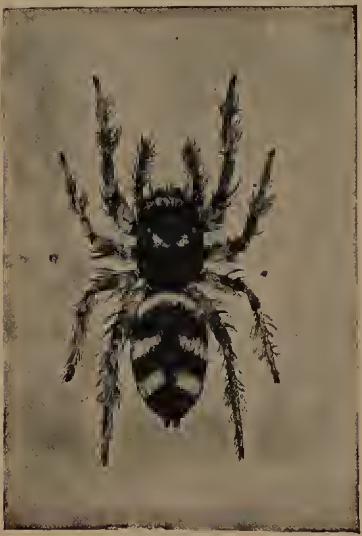

FIG. 35. — A jumping spider, *Salticus senicus*. (From the Spider Book, Doubleday, Page and Company.)

The eyes are arranged in three rows; those of the front middle pair are the largest, and are very conspicuous. These self-possessed spiders are able to stare an ordinary observer out of countenance. They move sidewise or backward with great ease, and can jump a long distance. They make no webs except nests in which they hide in winter or when moulting or laying eggs. They are hunters, pursuing their prey or springing upon it when it comes near them.

In certain members of this family the body is longer than in the typical forms, and ant-like in appearance.

Order ACARINA

The Mites

In this order the abdomen is unsegmented and broadly and closely joined with the thorax usually giving the entire body a more or less sac-like appearance. In many members of this order the body is divided into two regions which resemble the cephalothorax and abdomen of other arachnids but really the regions are not the same in their structure and make up. In many mites the body is marked by numerous transverse, fine lines, which are so impressed as to appear like the divisions between minute segments (Fig. 38).

As a rule the chelicerae are of characteristic form and often chelate but in many of the mites and ticks they are modified into slender, needle-like organs, fitted for piercing and sucking.

As in most arachnids the normal number of legs is eight but almost always the newly-hatched young have only six legs (3 pairs) while the adult members of the gall-mites, family *Eriophyidæ*, have but two pairs of legs. With the exception of a few species the mites reproduce by laying eggs.

The majority of mites are very small but a few, especially the ticks, are of considerable size. The mode of life of the different members of this order varies greatly; some are parasitic upon animals; others infest living plants; and many feed upon dead animal or vegetable matter, thus acting as scavengers.

Among the mites that are parasitic upon animals are the various ticks, which are very common in the warmer parts of our country. The common cattle-tick (Fig. 36) of the southern states is a very injurious parasite of cattle because it not only sucks the blood of its host but it carries from one animal to another the organism which causes a serious fever among the cattle known commonly as Texas-fever but more properly splenic fever.

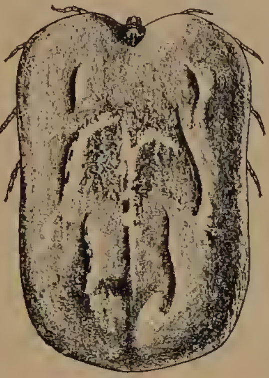
FIG. 36. — The southern cattle-tick, *Boophilus annulatus*.

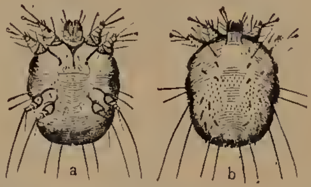

FIG. 37. — An Itch-mite: *a*, from below; *b*, from above.

The itch-mite is a well-known parasite, infesting man and causing the disease known as itch. The sensation characteristic of this disease is due to the burrowing of the mites in the skin; and the efficiency of sulphur ointment in checking this disease is due to the fact that by the use of it the mites are killed. Figure 37 represents an itch-mite greatly enlarged.

Parasitic mites are frequently found attached to insects; a common species occurs beneath the wings of locusts.

The best known of the mites that infest plants is the one commonly called the red spider. This lives upon house-plants; and in the warmer parts of the country, it infests fruit-trees, cotton, and other plants in the open air. On house-plants and in the greenhouse it can be subdued by a liberal use of water.

Some of the mites that infest plants produce galls. These galls are of various forms, but differ from those produced by gall-flies (Family *Cynipidæ* of the Order *Hymenoptera*) in having open mouths, from which the young mites escape.

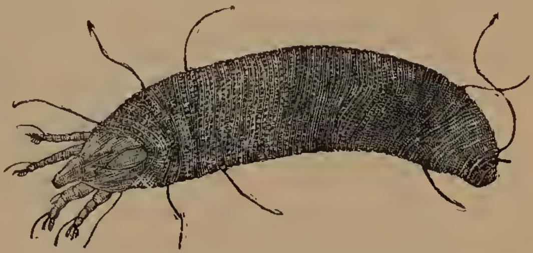
FIG. 38. — *Phyllocoptes pyri*, greatly enlarged.

A common disease of the pear, caused by the pear-leaf blister-mite, is produced by a four-legged mite *Phyllocŏptes pyrī*, (Fig. 38). The blisters characteristic of the disease are swellings of the leaf, within which there is a cavity affording a residence for the mites. Figure 39 represents a section of a leaf through one of these galls. Here the leaf is seen to be greatly thickened at the diseased part. On the lower side there is an opening through which the mite that started the gall entered, and from which young mites developed in the gall can escape, in order to start new galls. The infested leaves become reddish in color but finally turn black and drop off. Badly infested trees fail to develop good fruit and buds are not produced for the succeeding crop. Apple trees are also badly infested by this mite. The mite can be controlled by spraying the trees with lime-sulphur solution in the early spring before the buds burst.

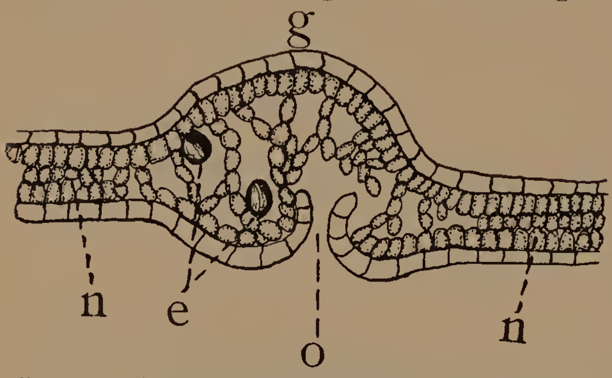

Fig. 39. — Diagram of gall of *Phyllocoptes pyri: g*, gall; *n*, *n*, normal structure of leaf; *o*, opening of gall; *e*, eggs. (After Soraur).

Among the scavenger mites there are some that infest food products. Thus mites are sometimes found in cheese, in sugar, and in preserved meats.

Class DIPLOPODA

The Millipedes or Diplopods

The members of this class are air-breathing arthropods in which the head is distinct, and the remaining segments of the body form a continuous region. The greater number of the body-segments are so grouped that each apparent segment bears two pairs of legs. The antennæ are short and very similar to the legs. The openings of the reproductive organs are paired, and situated behind the second pair of legs.

The Diplŏpoda and the Chilŏpoda were formerly grouped together in the class, *Myriăpoda.* But this grouping has been abandoned, because it has been found that the Chilopoda are more closely allied to the insects than they are to the Diplopoda. Owing to the very general and long continued use of the term Myriapoda, the student who wishes to look up the literature on these two classes should consult the references under this older name.

The most distinctive feature of the millipedes is that which suggested the name Diplopoda for the class, the fact that throughout the greater part of the length of the body there appear to be two pairs of legs borne by each segment (Fig. 40).

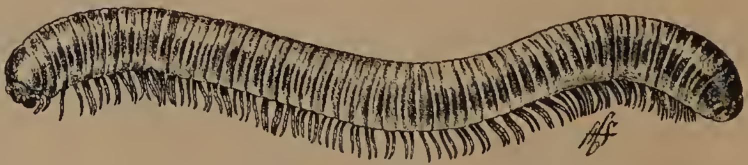

Fig. 40. — A millipede, *Spirobolus marginatus.*

This apparent doubling of the legs is due to a grouping of the segments in pairs and either a consolidation of the terga of each pair or the non-development of one of them; which alternative is the case has not been definitely determined.

Most of our more common millipedes possess stink-glands, which open by pores on a greater or less number of the body-segments. These glands are the only means of defence possessed by millipedes, except the hard cuticula protecting the body.

The millipedes as a rule are harmless, living in damp places and feeding on decaying vegetable matter; but there are a few species that occasionally feed upon growing plants.

Class CHILOPODA

The Centipedes or Chilopods

The members of this class are air-breathing arthropods in which the head is distinct, and the remaining segments of the body form a continuous region. The numerous pairs of legs are not grouped in double pairs, as in the Diplopoda. The antennæ are long and many-jointed. The appendages of the first body-segment are jaw-like and function as organs of offense, the poison jaws. The opening of the reproductive organs is in the next to the last segment of the body.

The animals constituting the class Chilopoda are commonly known as centipedes. They vary to a considerable degree in the form of the body, but in all except a few forms the body-segments are distinct, not grouped in couples as in the diplopods (Fig. 41). They are sharply distinguished from the preceding class in the possession of poison-jaws and in having the opening of the reproductive organs at the caudal end of the body. The body is usually flattened.

Many species of centipedes are venomous. The poison glands open through the appendages of the first body-segment. These organs are leg-like in form and are bent forward so as to act with the mouth-parts. These creatures abound in all parts of the United States; those which are found in the North are comparatively small, and rarely, if ever, inflict serious injury to man; but the larger species, which occur in the warmer regions, are unquestionably venomous.

The centipedes are predacious, feeding on insects; they usually live under stones, logs, and bark. There is one species, the house centipede, *Scutĭgera fŏrceps*, which has fifteen pairs of very long legs and which is often present running on the walls of dwelling houses, especially in the warmer regions of the United States. It hunts for flies and other insects and appears to be harmless to man. It prefers damp situations; in houses it is most frequently found in cellars, bathrooms, and closets. Sometimes it becomes very abundant in warm, moist conservatories.

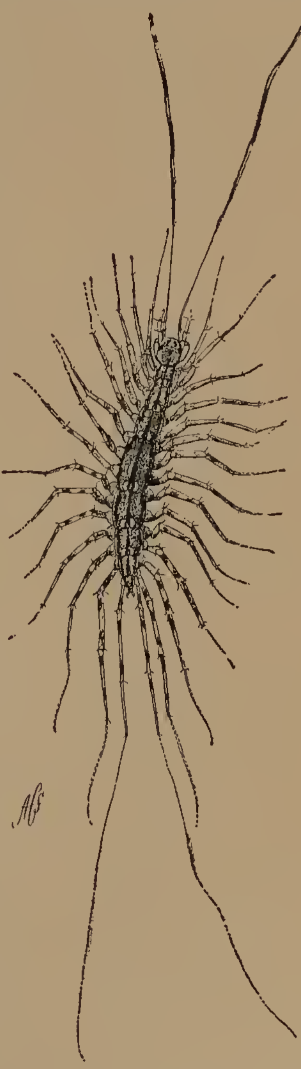

Fig. 41. — *Scutigera forceps.*

CHAPTER II

CLASS HEXAPODA

The Insects

The members of this class are air-breathing Arthropoda, with distinct head, thorax, and abdomen. They have one pair of antennæ, threee pairs of legs, and usually one or two pairs of wings in the adult state. The opening of the reproductive organs is near the caudal end of the body.

There are about us on every side myriads of tiny creatures that are commonly passed unnoticed, and even when observed, they are usually thought to be unworthy of serious consideration. But all life is linked together in such a way that no part of the chain is unimportant. Frequently the action of some of these minute beings seriously affects the material success or failure of a great commonwealth. The introduction and spread of a single species of insect (the cottony-cushion scale) in California threatened the destruction of the extensive orchards of that State; thousands of trees perished. The introduction of a few individuals of a particular kind of lady-bug (*Rodōlia cardinālis*), which feeds upon this pest and multiplies rapidly, soon checked the pest, and averted the disaster.

But insects are of interest to us for other reasons than the influence they may have upon our material welfare; the study of them is a fruitful field for intellectual growth. It is not a small matter to be able to view intelligently the facts presented by the insect world, to know something of what is going on around us. And so extensive and complex is this field that no one gains more than a mere smattering concerning it.

We know as yet comparatively little about the minute structure of insects; the transformations and habits of the greater number of species have not been studied; and the blood-relationship of the various groups of insects is very imperfectly understood. If, therefore, one would learn something of the action of the laws that govern the life and development of organized beings, and at the same time experience the pleasure derived from original investigation, he cannot find a better field than is offered by the study of insects.

But it is not necessary that one should have the tastes and leisure required for careful scientific investigation in order to profit by this study. It can be made a recreation, a source of entertainment when we are tired, a pleasant occupation for our thoughts when we walk. Any one can find out something new regarding insect architecture — the ways in which these creatures build nests for themselves or for their young. It is easy to observe remarkable feats of engineering, wonderful industry, unremitting care of young, tragedies, and even war and slavery.

The abundance of insects makes it easy to study them. They can be found wherever man can live, and at all seasons. This abundance is even greater than is commonly supposed. The number of individuals in a single species is beyond computation: who can count the aphids or the scale-insects in a single orchard, or the bees in a single meadow?

Not only are insects numerous when we regard individuals, but the number of species is far greater than that of all other animals taken together. The number of species in a single family is greater in several cases than the number of stars visible in a clear night.

The word *insect* is often applied incorrectly to any minute animal; but the term should be restricted to those forms possessing six legs and belonging to the class, Hexapoda. Thus spiders, which have eight legs, are not insects.

The name *Hexapoda* is from two Greek words: *hex*, six; and *pous*, foot. It refers to the fact that the members of this order differ from other arthropods in the possession of only six feet.

Insects breathe by means of a system of air-tubes (tracheæ) which extends through the body. This is true even in the case of those that live in water and are supplied with gill-like organs (the tracheal gills; see p. 39). The head is distinct from the thorax, and bears a single pair of antennæ; in these respects they are allied to the millipedes and centipedes although they are apparently more closely related to a small group of animals known as symphylids of the class, *Symphyla* (see "An Introduction to Entomology" by J. H. Comstock).

They can be easily distinguished by the number of their feet, and, usually, also by the presence of wings.

The Metamorphoses of Insects

Nearly all insects in the course of their lives undergo remarkable changes in form. Thus the butterfly, which delights us with its airy flight, was at one time a caterpillar; the bee, which goes so busily from flower to flower, lived first the life of a clumsy, footless grub; and the graceful fly was developed from a maggot.

In the following pages considerable attention will be given to descriptions of the changes through which various insects pass. It is our wish in this place merely to define certain terms which are used in describing these changes.

Development without metamorphosis. — In two of the orders of insects, the Thysanura and Collembola, the young insect just hatched from the egg is of the same form as the adult insect. These insects merely grow larger, without any more marked change in form than takes place in our own bodies during our life. They are said, therefore, to develop without metamorphosis.

Incomplete or gradual metamorphosis. — There are many insects which undergo a striking change of form during their life, although the young greatly resembles the adult. Thus a young locust just out from the egg can be easily recognized as a locust. It is of course much smaller than the adult, and is not furnished with wings. Still the form of the body is essentially the same as that of the adult (Fig. 42). (The hair-line above the figure indicates the natural size of the insect.) After a time rudimentary wings appear; and these increase in size from time to time till the adult state is reached (Figs. 43 to 47). During this development there is no point at which the insect passes into a quiescent state corresponding to the chrysalis state of a butterfly. Those insects which, like the locust, when they emerge from the egg resemble in form the adult, but still undergo some change, are said to undergo an incomplete metamorphosis. In other words, after leaving the egg they do not undergo a complete change of form.

There are many other insects besides locusts which have an incomplete metamorphosis. For example, crickets, cockroaches, aphids, the true bugs, cicadas, scale-insects, *et al.*

The young of three orders of insects, the stoneflies (*Plecoptera*), the mayflies (*Ephemerida*) and the dragonflies (*Odonata*) are adapted for living in the water and most of them pass through somewhat more complicated changes than do the nymphs of locusts. For these reasons perhaps they ought to be included in a group by themselves and designated as having a special phase of metamorphosis; but for the sake of simplicity we have placed them among the insects having a gradual or incomplete metamorphosis.

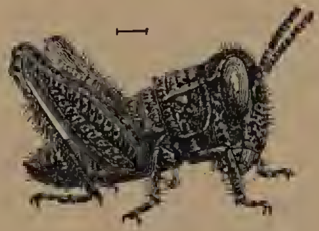
Fig. 42. — Nymph of *Melanoplus*, first stage. (After Emerton.)

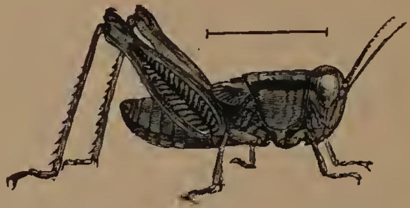
Fig. 45. — Nymph of *Melanoplus*, fourth stage. (After Emerton.)

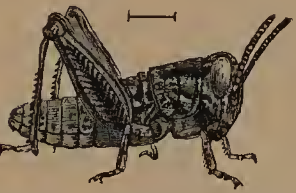
Fig. 43. — Nymph of *Melanoplus*, second stage. (After Emerton.)

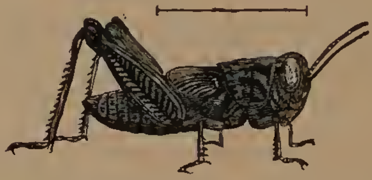
Fig. 46. — Nymph of *Melanoplus*, fifth stage. (After Emerton.)

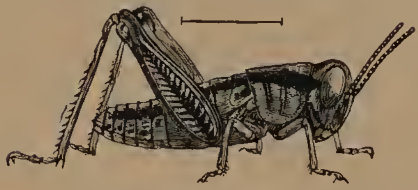
Fig. 44. — Nymph of *Melanoplus*, third stage. (After Emerton.)

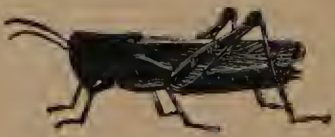
Fig. 47. — *Melanoplus*, adult.

The nymph. — The young of all insects with incomplete metamorphoses are known as *nymphs*. The term nymph is applied to all stages of such insects from the time they hatch until they shed their skin for the last time. When a nymph first hatches it has no signs of wings; but after it molts once or twice one or two projections appear on each side of the thorax in the case of those forms in which the adult has wings. These projections become larger and larger and more wing-like in form with each successive molt.

The important feature of insects having an incomplete metamorphosis is that the wings develop externally. That is, the wings of nymphs are sac-like outgrowths of the body-wall which appear early and grow larger as already explained.

Complete metamorphosis. — Other insects, like the bees, butterflies, moths, flies, and beetles leave the egg in an entirely different form from that which they assume when they reach maturity. A butterfly begins its active life as a caterpillar. It feeds and grows, and when full-grown changes to a chrysalis. In this stage it has very little resemblance to a caterpillar. After a time there bursts forth from the chrysalis shell the butterfly, which looks very little like the chrysalis and still less like the caterpillar from which it came. In a similar way, from the egg laid by a fly upon a piece of meat there hatches, not a fly, but a footless, worm-like maggot. This when fully grown changes to a quiescent object corresponding to the chrysalis of a butterfly. Later from this object there escapes a winged fly like that which laid the egg. Those insects, like the butterflies and flesh-flies which when they emerge from the egg bear almost no resemblance in form to the adult insect, are said to undergo a complete metamorphosis. In other words, the change of form undergone by the insect is a complete one, and it passes through the following stages: —

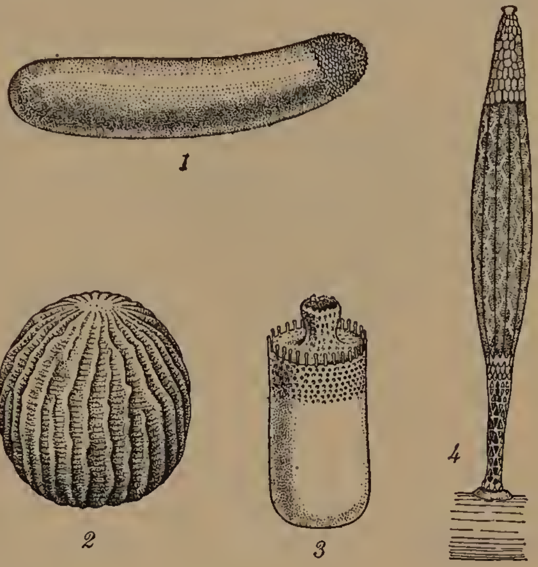

Fig. 48. — Eggs of insects; *1, Œcanthus nigricornis; 2, Œnis semidea; 3, Piezosterum subulatum; 4, Hydrometra martini.*

The egg. — This is the first stage in the existence of any insect, although in some instances the egg remains in the body of the mother till it hatches. But almost always the eggs are laid by the mother insect on or near the food which gives nourishment to the young. Many of the most interesting habits of insects are connected with the care of the eggs by the parent. The eggs may have smooth oval shells; but often the shells are beautifully ribbed and pitted (Fig. 48), and sometimes they are ornamented with spines, and are frequently exquisitely colored.

The larva. — This is the second stage of an insect with a complete metamorphosis and is the form that hatches from the egg. Familiar examples of larvæ are caterpillars (Fig. 49), maggots, and grubs. In fact, many creatures popularly known as worms are larvæ of insects. Away from the ocean we find but few worms, except earthworms, leeches, "hair-snakes," and worm-parasites in the intestines of men and animals. The larval stage is devoted to growth; the sole business of a larva being to eat and grow. All molting, because of increased size, is done in the larval stage, later molts are simply for change of shape.

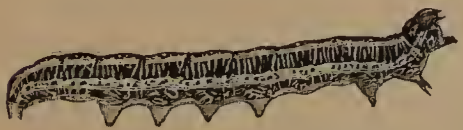

Fig. 49. — A caterpillar, the larva of a moth.

The pupa. — This is the third stage in the life of many insects, and is ordinarily a period of inaction, except that rapid and wonderful changes go on within the body. Very few pupæ, like those of mosquitoes, are active. Usually pupæ have no power of moving around, but many of them can squirm when disturbed. When the last skin of the larva is thrown off the pupa is revealed; it is an oblong object, and frequently apparently headless and footless. In many pupæ the skin is a shiny covering like porcelain. If a pupa be examined closely the antennæ and legs and wings may be seen; these are folded up closely and soldered to the breast in the case of the moths and butterflies (Fig. 50), but free in case of the bees, ants, and beetles.

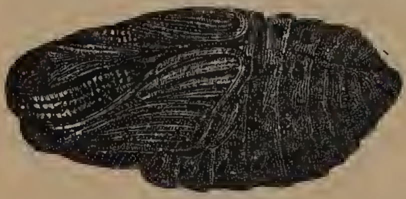

Fig. 50. — A pupa of a large moth.

The chrysalis. — This term is often applied to the pupa of a butterfly. The word is derived from a Greek word meaning gold, and came into use because of the golden dots and markings on many of the butterfly pupæ.

The cocoon. — Many larvæ, especially those of moths, when full grown, spin about the body a silken case, so that when they change to helpless pupæ they may be protected from enemies, and from rain and snow; these silken cases are called cocoons. They are frequently made within a rolled leaf (Fig. 51), or beneath grass and rubbish on the ground, or in cells below the ground. Some hairy caterpillars make cocoons largely of their own hairs, which they fasten together with a film of silk.

The important characteristic of insects having a complete metamorphosis is that the wings develop internally. The wings begin to form in the young larvæ, caterpillars of butterflies, as buds of the hypodermis underneath the cuticula and appear for the first time when the last larval skin is shed.

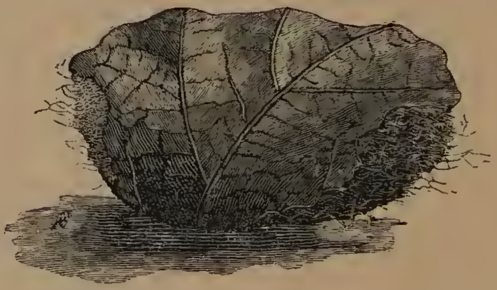

Fig. 51. — A large cocoon within a rolled leaf.

Imago. — A fully developed or adult insect is called an *imago*. The imagos of most insects except those of the orders Thysanura and Collembola have wings although there are many cases where wings have been lost through disuse. An insect never grows or molts after it reaches the adult stage. There is a popular belief that a small fly will grow into a large fly, but this is not true, for after any insect gets its perfect wings it can grow no larger, except that in case of females the body may be distended by the growth of eggs within it. While many adults eat more or less, it is only to sustain life, and not for growth. Indeed, many adult insects take very little food, and some have lost their mouth-parts entirely, through disuse. The adult stage usually lasts for a considerably shorter time than the larval or nymph stages. In fact, it seems planned in the economy of nature that the grown-up insects should live only long enough to lay eggs, and thus secure the perpetuation of the species. For example, mayflies live but a few days or even but a few hours,—just long enough, apparently, to lay their eggs and provide for the perpetuation of the species.

HOW INSECTS GROW

It has already been pointed out that a small fly does not grow into a large fly. No insect grows after it becomes an imago. All growth of an insect takes place in the young stages and larval and nymphal stages; and growth in these immature stages is accompanied by a shedding or molting of the outer skin.

Molting. — The outer skin of a nymph or of a larva consists in large part of a substance known as chitin. In the young insect this outer skin soon becomes so firm and hard that it will not stretch enough to allow for the growth of the insect. The result is that from time to time the skin of the young insect becomes too small for it and must be shed. But before this is done a new skin is formed beneath the old one; then the old skin bursts open, and the insect crawls forth, clothed in a soft skin, which stretches to accommodate the increased size of the individual. Very soon, however, this new skin becomes hardened, and after a time it in turn must be shed. This shedding of the skin is termed molting, and the cast skin is sometimes referred to as the *exuviæ*. Insects differ greatly as to the number of times they molt: many species molt only four or five times, while others are known to molt more than twenty times. Figure 52 represents the cast skin of a dragonfly clinging to a reed.

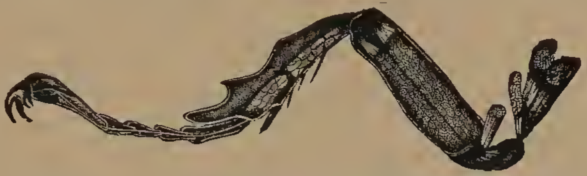
FIG. 53. — Leg of May-beetle. (After Straus-Durckheim.)

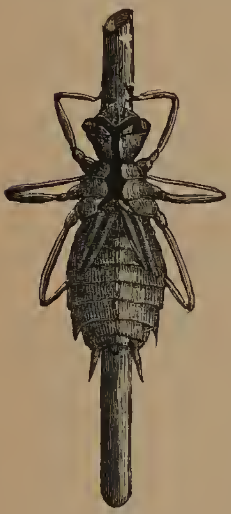
FIG. 52. — Exuviæ of nymph of dragonfly.

THE EXTERNAL ANATOMY OF INSECTS

The subject of insect anatomy is separated into two divisions: one, treating of the structure of the body-wall or skeleton; the other, of the internal organs. The former is termed *external anatomy;* the latter, *internal anatomy.*

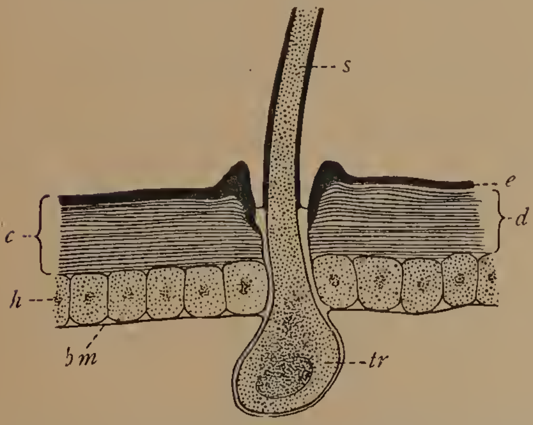

FIG. 54. — A section of the body-wall of an insect: *c*, cuticula; *h*, hypodermis; *bm*, basement membrane; *e*, epidermis, *d*, dermis; *tr*, trichogen; *s*, seta.

In our own bodies we find a central framework or skeleton, about which are arranged the muscles, blood-vessels, nerves, and other organs. But insects are constructed on an entirely different plan; with them the supporting skeleton is outside, and the muscles, nerves, and other organs are within this skeleton. The difference can be well seen if the figure showing the internal structure of the leg of a may-beetle (Fig. 53) be compared with one of our own limbs, either arm or leg.

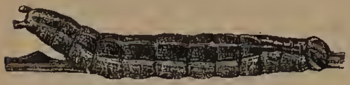
Fig. 55. — A Larva.

The body of an insect is built on the same plan as are its legs. The outside of the body is more or less firm, and this firm outer wall supports the muscles and other organs, thus serving as a skeleton. The skeleton is therefore, in general outline, a hollow cylinder.

The outer body-wall is composed of three layers: (1) an outer protective layer, the *cuticula*; (2) a middle layer, the *hypodermis;* and (3) an inner delicate thin layer, the *basement membrane* (Fig. 54). The cuticula is a tough sheet of chitin often hardened by the deposition in it of other substances.

The cuticula is not hardened throughout but remains soft and flexible at certain transverse indentations running around the body. These soft places in the cuticula mark the divisions between the ring-like portions of the body called *segments.*

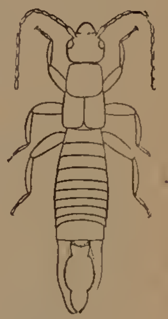
Fig. 56. — An earwig.

In this way provision is made for the various motions of the body. The ring-like nature of the segments of the body is best seen in larvæ (Fig. 55), and in the abdomen of an adult insect (Fig. 56). The movements of the legs, antennæ, and certain other appendages are provided for in the same way; each one is a cylinder made up of several segments, and between these segments the wall of the cylinder remains flexible.

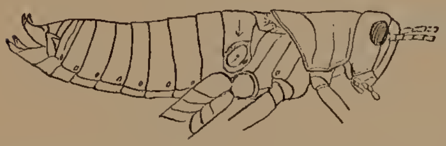
Fig. 57. — Side-view of locust with wings removed.

When a single segment of the body is examined, its cuticula is not found to be a continuous ring, but is seen to be made up of several portions more or less movable upon each other. Such a hardened portion of the cuticula is termed a *sclerite.*

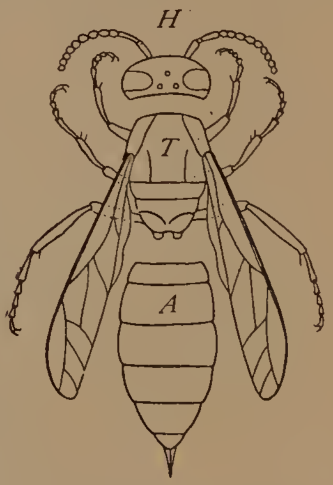

Fig. 58. — Wasp, with head, thorax, and abdomen separated.

The sclerites constitute the greater part of the cuticula, the soft membranous portions separating them being in most cases narrow. Usually these narrow portions are mere lines; they are then called *sutures.*

Frequently the sutures become entirely effaced. We are therefore often unable to distinguish certain sclerites in one species of insect which we know to exist in another. In such cases the effaced sutures are said to be *obsolete.*

If the central portion or thorax of an adult insect be examined, numerous sclerites and sutures can be observed (Fig. 57).

The subject of external anatomy of insects consists very largely in a study of the sclerites of which the different segments of the body and of its appendages are composed. This part of the subject is quite difficult, and will not be discussed here. It is treated, however, in the discussion of the characters used in the classification of the Coleoptera given on pages 128 to 130. These pages should be carefully studied before attempting to use the table that follows them.

The segments of the body in a fully developed insect are grouped into three regions: head, thorax, and abdomen (Fig. 58). In the larval state this grouping of the segments is not well shown.

The Head and its Appendages

The head is the first of the three regions of the body formed of several body-segments grown together.

The head bears the compound eyes, the simple eyes or ocelli, the antennæ, and the mouth-parts.

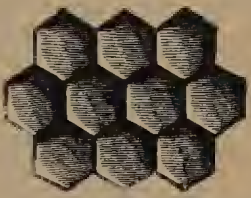

Fig. 59. — Part of surface of compound eye, greatly enlarged.

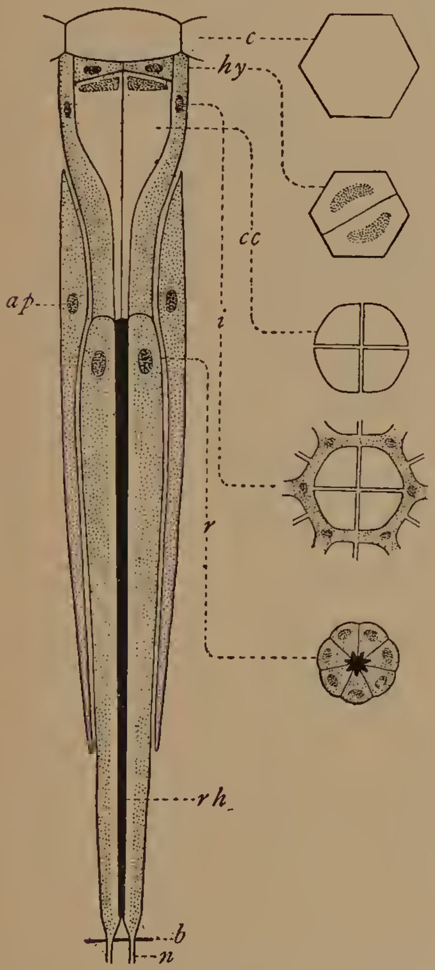

Fig. 60. — An ommatidium of *Machilis* c, cornea; *hy*, corneal hypodermis; *cc*, crystalline-cone-cells; *i*, iris-pigment cells; *r*, retinula cells; *rh*, rhabdom; *b*, basement membrane; *ap*, accessory pigment cells.

The compound eyes. — On each side of the head of an adult insect is an organ, which is recognized at once as an eye. But when one of these eyes is examined with a microscope it is found to present an appearance very different from that of the eye of higher animals; its surface is divided into a large number of six-sided divisions (Fig. 59). A study of the internal structure of this organ has shown that each of these hexagonal divisions is the outer end of a distinct portion or element of the eye (Fig. 60). Hence what at first appears to be a single eye is really an organ composed of hundreds of distinct structures; it is termed, therefore, a compound eye. Each of the small elements of which a compound eye is composed is termed an *ommatidium* (plural ommatidia). The number of ommatidia of which a compound eye is composed varies greatly: there may be not more than fifty, as in certain ants, or there may be many thousand, as in a butterfly or a dragonfly. Compound eyes are not found in larvæ, though they may possess a group of simple eyes on each side of the head.

The simple eyes. — In addition to the compound eyes, many adult insects possess simple eyes. These are situated between the compound eyes. They vary in number from two to three; the most common number is three (see Fig. 58). The simple eyes are termed ocelli.

Nymphs also possess ocelli but in the case of most larvæ there are simple eyes which are different in origin from the ocelli of adult insects.

The antennæ. — The antennæ are a pair of jointed appendages articulated with the head in front of the eyes or between them. They vary in form. In some insects they are thread-like, consisting of a series of similar segments; in others certain segments are greatly modified in form.

The various forms of antennæ are designated by special terms. The more common of these forms are represented in Figure 61. These are as follows:

1. Setaceous or bristle-like, in which the segments are successively smaller and smaller, the whole organ tapering to a point.

2. Filiform or thread-like, in which each segment is of nearly uniform thickness throughout its length; and the antenna as a whole tapers gradually, if at all, towards the tip.

3. Moniliform or necklace-form, in which the segments are more or less globose, suggesting a string of beads.

4. Serrate or saw-like, in which the segments are triangular, and project like the teeth of a saw.

5. Pectinate or comb-like, in which the segments have long processes on one side, like the teeth of a comb, or on both sides, like a feather.

6. Clavate or club-shaped, in which the segments become gradually broader, so that the whole organ assumes the form of a club.

7. Capitate or with a head, in which the terminal segment or segments form a large knob.

8. Lamellate in which the segments that compose the knob are extended on one side into broad plates.

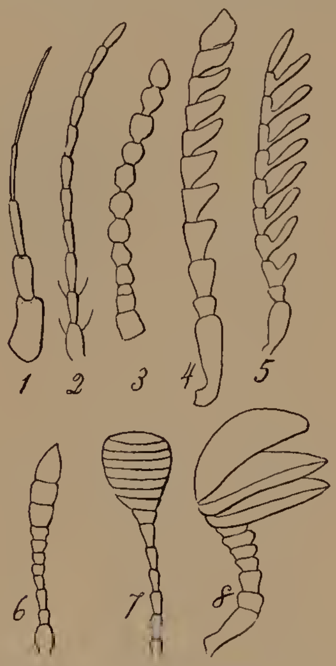

FIG. 61. — Various forms of antennæ.

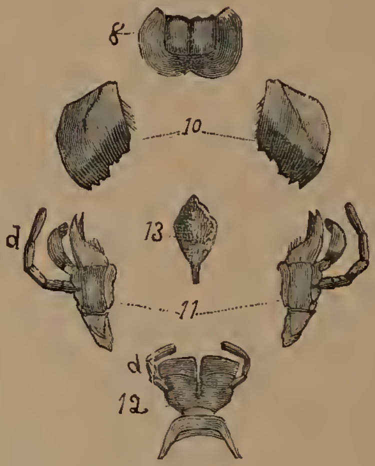

FIG. 62. — Mouth-parts of the red-legged Locust.

The mouth-parts. — No organs in the body of an insect vary in form to a greater degree than do the mouth-parts. Thus with some the mouth is formed for biting, while with others it is formed for sucking. Among the biting insects some are predacious, and have jaws fitted for seizing and tearing their prey; others feed upon vegetable matter, and have jaws for chewing this kind of food. Among the sucking insects the butterfly merely sips the nectar from flowers, while the mosquito needs a powerful instrument for piercing its victim. In this place the typical form of the mouth-parts as illustrated by the biting insects is described. The various modifications of it presented by the sucking insects are described later, in the discussion of the characters of those insects.

In the biting insects, the mouth-parts consist typically of an upper lip, the *labrum* (Fig. 62, 8); an under lip, the *labium* (Fig. 62, 12); and two pairs of jaws between them. These jaws open sidewise, instead of in a vertical direction, as do the jaws of the higher animals. The jaws of the upper pair are called the *mandibles* (Fig. 62, 10); the lower pair, the *maxillæ* (Fig. 62, 11). There may be also within the mouth one or two tongue-like organs, the *epipharynx* and *hypopharynx* (Fig. 62, 13). The epipharynx is attached to the upper wall of the cavity of the mouth, and the hypopharynx to the lower. The position of the hypopharynx is quite analogous, therefore, to that of our tongue.

The mandibles vary much in form, but usually each consists of a single sclerite. The maxillæ of biting insects, on the other hand, are very complicated organs, each composed of several sclerites. Each maxilla bears an appendage consisting of several segments; these appendages are termed the *maxillary palpi*. In the maxillæ of certain biting insects, as the grasshoppers and the ground beetles, there is an appendage usually consisting of two segments: this is the *galea* or *outer lobe*. In some of these insects, as the ground-beetles and the tiger-beetles, the galea is shaped like a plapus, and thus there appear to be two pairs of maxillary palpi (Fig. 63). The labium is furnished with a pair of jointed appendages; these are the *labial palpi* (Fig. 62, 12, *d*).

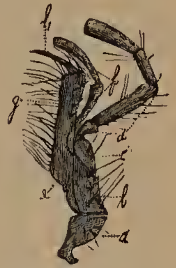

Fig. 63. — Maxilla of a tiger beetle; *a*, palpus.

The Thorax and its Appendages

The thorax is the second or intermediate region of the body; it is the region that bears, in the adult insect, the organs of locomotion, the legs, and the wings when they are present. This region is composed of three of the body-segments more or less firmly joined together; the segments are most readily distinguished by the fact that each bears a pair of legs. In winged insects, the wings are borne by the second and third segments. The first segment of the thorax, the one next to the head, is named the *prothorax;* the second thoracic segment is the *mesothorax;* and the third, the *metathorax*.

The legs. — Each leg consists of the following parts, beginning with the one next to the body (see Fig. 64): *coxa*, *trochanter*, *femur*, *tibia*, and *tarsus*. Each of these parts consists of a single segment except that in certain Hymenoptera the trochanter consists of two segments (Fig. 64, *t*), and in most insects the tarsus consists of several segments. The number of segments of the tarsus usually varies from one to five. Frequently the first segment of the tarsus is much longer than either of the other segments, and it may also differ greatly in form from them; under such circumstances it is sometimes designated the *metatarsus* (Fig. 64). The last segment of the tarsus usually bears one or two claws.

On the ventral surface of the segments of the tarsus in many insects are cushion-like structures termed *pulvilli.* In many insects the pulvilli of the last segment of the tarsus are circular pads beneath the tarsal claws. In most descriptive works these are referred to as *the* pulvilli, even though the other pulvilli are well developed.

The pulvilli of some insects, notably those of the Diptera, bear fine, hollow hairs, called *tenent* hairs, from which an adhesive fluid exudes that enables the insect to walk on the undersides of objects.

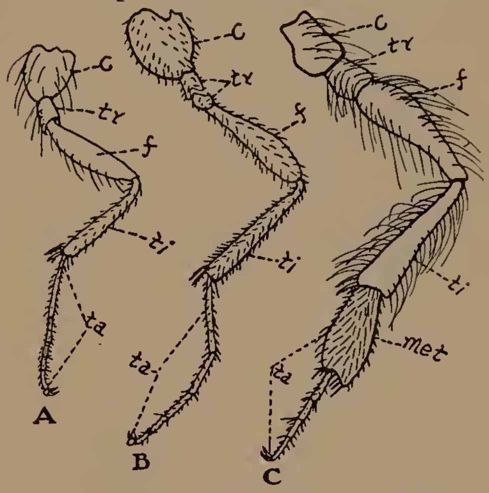

Fig. 64. — Legs of insects: A, wasp; B, ichneumon-fly; C, bee; *c*, coxa; *tr*, trochanter; *f*, femur; *ti*, tibia; *ta*, tarsus; *met.*, metatarsus.

The wings. — The two pairs of wings are borne by the mesothorax and metathorax, but either or both pairs may be wanting. Thus the flies, or *Diptera*, have only the first pair of wings fitted for flight, the second pair being represented by a pair of knobbed threads; and with the earwigs and beetles each of the first pair of wings is hard and together they form a cover for the hind pair.

In form an insect's wing is a large, membranous, leaf-like appendage, which is thickened along certain lines. These thickened lines are termed the *veins* or *nerves* of the wing; and their arrangement is described as the *venation* or *neuration* of the wings. The thin spaces of the wings which are bounded by the veins are called *cells.* When a cell is completely surrounded by veins it is said to be *closed;* but when it extends to the margin of the wing it is said to be *open.*

The wings of different insects vary greatly in structure, and thus afford excellent distinctions for the purposes of classification. The various parts of the wing have, therefore, received special names. There is considerable lack of uniformity among entomologists as to the names applied to these parts; but we have adopted the set of terms defined below as representing the best usage.

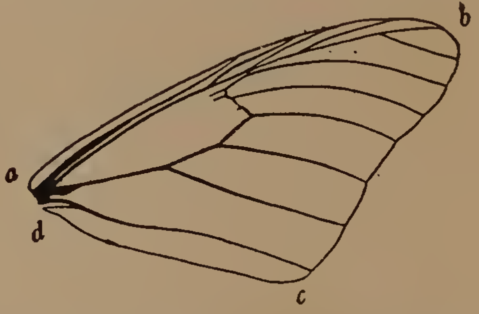

Fig. 65. — Diagram of a wing showing margins and angles.

An insect's wing is more or less triangular in outline; it therefore presents three margins: the *costal margin*, or *costa* (Fig. 65, *a–b*); the *outer margin* (Fig. 65, *b–c*); and the *inner margin* (Fig. 65, *c–d*).

The angle at the base of the costal margin (Fig. 65, *a*) is the *humeral angle;* that between the costal margin and the outer margin (Fig. 65, *b*) is the *apex* of the wing; and the angle between the outer margin and the inner margin (Fig. 65, *c*) is the *anal angle.*

There have been many different sets of names applied to the veins of the wings. Not only have the students of each order of insects had a peculiar nomenclature, but in many cases different students of the same order of insects have used different sets of terms. This condition of affairs was incident to the beginning of the science, the period before the correspondence of the veins in the different orders had been worked out. But now the time has come when it seems practicable to apply a uniform nomenclature to the wing veins of all orders; and the following set of terms is proposed for that purpose.

The principal veins of the wing, those that arise at or near the base of the wing, are termed, beginning with the one lying on the costal margin, the *costa*, the *subcosta*, the *radius*, the *media*, the *cubitus*, and the *anal veins*. The radius, media, and cubitus are usually branched, and there may be several anal veins.

In addition to the principal or longitudinal veins, there may be a greater or less number of *cross-veins* — veins extending transversely from one longitudinal vein to another.

The principal veins may be designated by numbers as well as by names; the following table indicates the correspondence of the names and numbers:

Costa = vein I.
Subcosta = vein II.
Radius = vein III.
Media = vein V.
Cubitus = vein VII.
1st anal vein = vein VIII.
2d anal vein = vein IX.
3d anal vein = vein XI.

It was formerly believed that in certain insects three other longitudinal veins were present; these were numbered IV, VI, and X respectively; hence these numbers are omitted in the above table.

At the time the first edition of this book was written, it was thought best to designate the veins by numbers; but owing to a lack of uniformity in the numbering of the veins by different writers, it is now clear that the names are to be preferred. In the lettering of figures, abbreviations of the names can be used as is done in Figure 66.

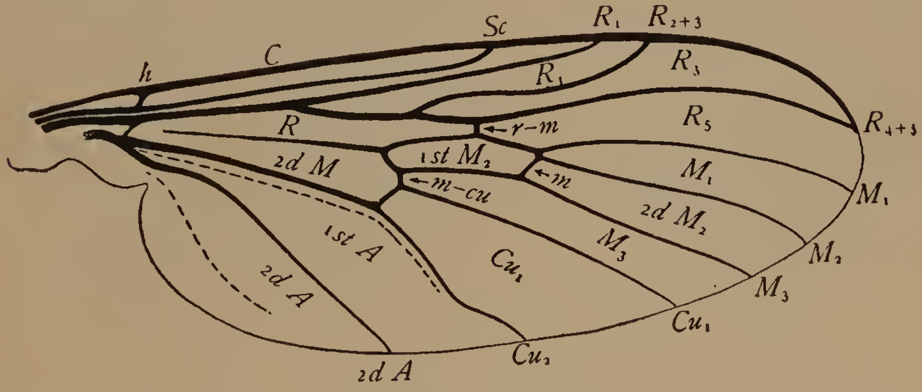

FIG. 66. — Wing of a fly, *Anisopus*.

The divisions of a branched vein are numbered, beginning with the one nearest the costal margin of the wing; and these numbers are indicated by sub-figures. For example, the five branches of the typical radius are designated thus, R_1, R_2, R_3, R_4, R_5.

When two or more branches of a branched vein coalesce, the compound vein is designated by an expression indicating this coalescence, as R_{2+3}. In this way it is possible to indicate some of the changes that have taken place in the development of the species; and to make use of them in working out the classification of the group to which the species belongs.

The cells of the wing are designated by applying to each the number or the abbreviation of the name of the vein that forms its cephalic (front) margin. In Figure 66 the veins are designated by letters at the margin of the figure; the cells by letters within the figure. When a cell is divided by a cross-vein the parts are numbered, as in the case of cell M_2 in Figure 66.

The Abdomen and its Appendages

The *abdomen* is the third or caudal region of the body. Its segments are more simple, distinct, and ring-like than those of the other regions. The number of segments of which it appears to be composed varies greatly. In the cuckoo-flies (*Chrysididæ*) there are usually only three or four visible, while in many other insects nine appear. Except in the lowest order of insects (*Thysanura*) the abdomen of the adult bears no locomotory appendages. But many larvæ have fleshy appendages which aid in locomotion: these are termed *prolegs*. In the adult the end of the body in many families is furnished with jointed filaments — the *cerci*, and *caudal setæ*. Frequently also the body is furnished in the male with organs for clasping — the *claspers;* and in the female with saws, piercers, or borers — the *ovipositor*. In the female of certain insects there is a *sting*, a modified ovipositor, which is used as an organ of defence; and the abdomen of plant-lice and certain other insects bears a pair of tubes or tubercles, through which a wax-like material is excreted: these are termed *cornicles*, or *siphuncles;* see page 115.

The Internal Anatomy of Insects

As has been shown in the preceding pages, the body-wall serves as a skeleton, being hard, and giving support to the other organs of the body. This skeleton may be represented, therefore, as a hollow cylinder. We have now to consider the arrangement and the general form of the organs contained in this cylinder. For the details of the structure of the internal organs the student is referred to more special works.

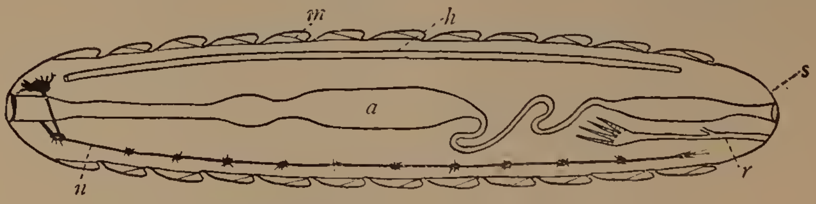

Fig. 67. — Diagram showing the relation of the internal organs.

The accompanying diagram (Fig. 67), which represents a vertical, longitudinal section of the body, will enable one to gain an idea of the relative position of some of the more important organs. The parts shown in the diagram are as follows: the body-wall, or skeleton (*s*); this is made up of a series of overlapping segments; that part of it between the segments is thinner, and is not hardened, thus remaining flexible and allowing for the movements of the body. Just within the body-wall,

PLATE II

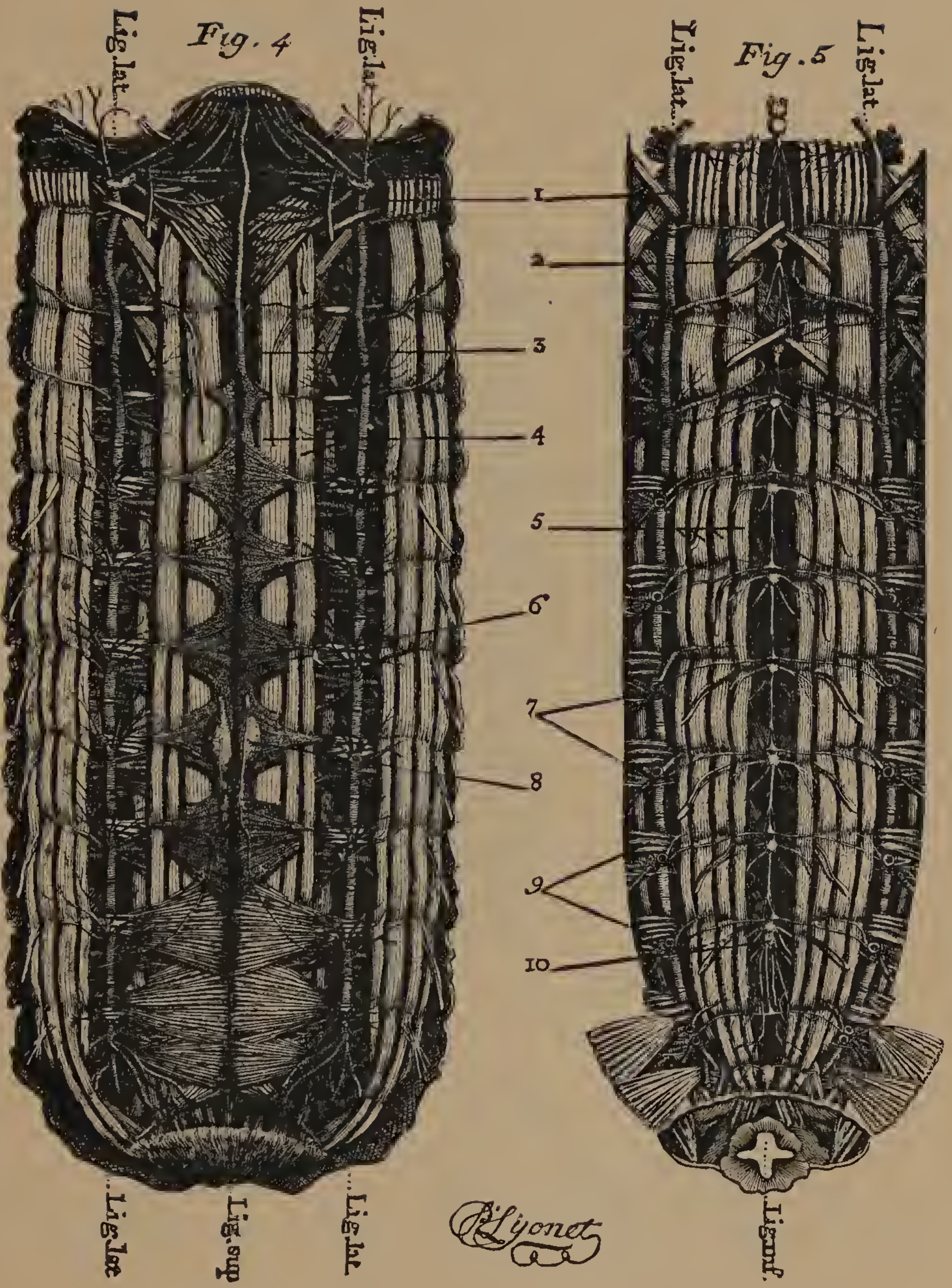
Lig.lat.
Fig. 4
Lig.lat.
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Fig. 5
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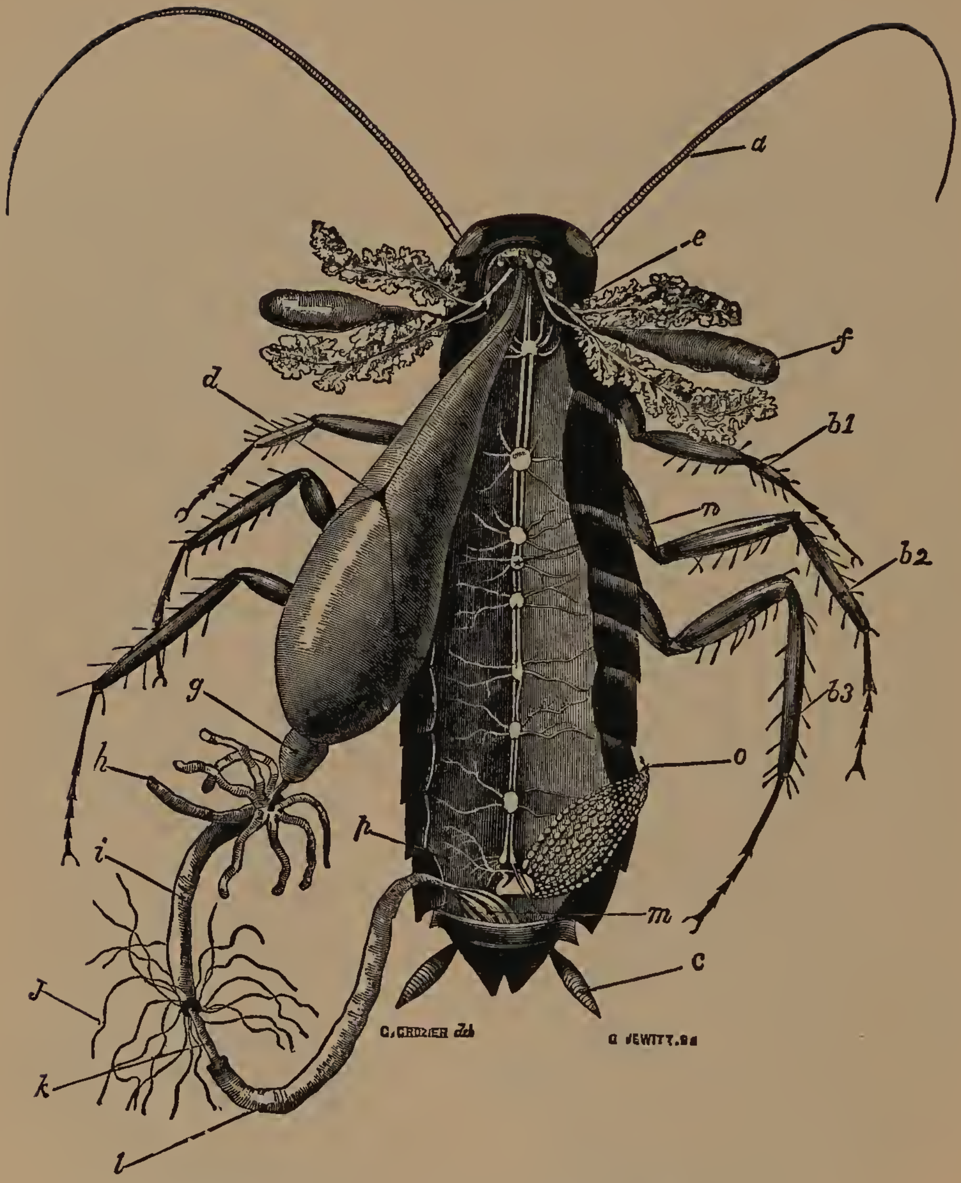
Lig.lat.
P. Lyonet
Lig.inf.

Internal Anatomy of a Caterpillar (*Cossus ligniperda*).

Fig. 4. — Caterpillar opened on the ventral middle line. Fig. 5. — Caterpillar opened on the dorsal middle line. 1, principal longitudinal tracheæ; 2, central nervous system; 3, aorta; 4, longitudinal dorsal muscles; 5, longitudinal ventral muscles; 6, wings of the heart; 7, tracheal trunks arising near spiracles; 8, reproductive organs; 9, vertical muscles; 10, last abdominal ganglion. (After Lyonet.)

PLATE III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Internal Anatomy of a Cockroach (*Periplaneta orientalis*).

a, antennæ; *b*1, *b*2, *b*3, legs; *c*, anal cerci; *d*, ganglion on recurrent nerve upon the crop; *e*, salivary duct; *f*, salivary bladder; *g*, gizzard; *h*, hepatic cœca; *i*, mid-intestine; *j*, Malpighian vessels; *k*, small intestine; *l*, large intestine; *m*, rectum; *n*, first abdominal ganglion; *o*, ovary; *p*, sebaceous glands. (From Rolleston.)

and attached to it, are represented a few of the muscles (m); it will be seen that these muscles are so arranged that the contraction of those on the lower side of the body would bend it down, while the contraction of those on the opposite side would act in the opposite direction. The alimentary canal (a) occupies the centre of the body, and extends from one end to the other. The heart (h) is a tube lying between the alimentary canal and the muscles of the back. The central part of the nervous system (n) is a series of small masses of nervous matter connected by two longitudinal cords: one of these masses, the brain, lies in the head above the alimentary canal; the others are situated, typically one in each segment, between the alimentary canal and the layer of muscles of the ventral side of the body; the two cords connecting these masses, or ganglia, pass one on each side of the œsophagus to the brain. The reproductive organs (r) lie in the cavity of the abdomen and open near the caudal end of the body. The respiratory organs are omitted from this diagram for the sake of simplicity.

The muscular system. — We find in insects a wonderfully large number of muscles. Those that move the segments of the body form several layers just within the body-wall. The two figures on Plate II represent two caterpillars which have been split open lengthwise, one on the middle line of the back and one on the opposite side; in each case the alimentary canal has been removed, so that only those organs that are attached quite closely to the body-wall are left. From a study of these figures some idea can be obtained of the number and arrangement of these muscles. It should be borne in mind, however, that only a single layer of muscles is represented in these figures — the layer which would be seen if a caterpillar were opened in the way indicated. When these muscles are cut away many other muscles are found extending obliquely in various directions between these muscles and the body-wall.

The muscles of insects appear very differently from those (the lean meat) of higher animals. In insects the muscles are either colorless and transparent, or yellowish-white; and they are soft, almost of a gelatinous consistency. The fibers of insect muscles are usually if not always of the striated type.

As a rule, the muscles of insects are composed of many distinct fibres which are not enclosed in tendinous sheaths as with vertebrates. But the muscles that move the appendages of the body are furnished with a tendon at the end farthest from the body (Fig. 68).

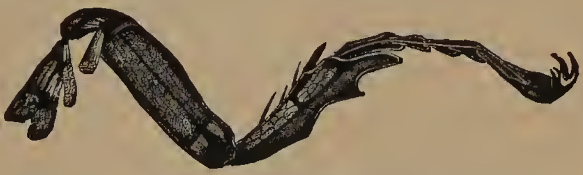
Fig. 68. — Leg of May-beetle. (After Straus-Durckheim.)

Notwithstanding the soft and delicate appearance of the muscles of insects, they are really very strong.

The alimentary canal. — The typical position of this is represented in the diagram (Fig. 67); and on Plate III, illustrating the anatomy of a cockroach, its form in that insect is shown. In larvæ it is a nearly straight tube, extending from one end of the body to the other. But in adult insects it is usually much longer than the body, and is consequently more or less folded. It is composed of parts differing in form and use. To these parts names have been given similar to those used to designate the corresponding parts in higher animals; thus we distinguish a *pharynx*, an *œsophagus*, sometimes a *crop*, sometimes a *gizzard*, a *stomach*, a *small intestine*, and a *large intestine*.

The adipose tissue, or fat. — On opening the body of an insect, especially of a larva, one of the most conspicuous things to be seen is fatty tissue, in large masses. These often completely surround the alimentary canal, and are held in place by numerous branches of the tracheæ with which they are supplied. Other and smaller masses of this tissue adhere to the inner surface of the abdominal wall, in the vicinity of the nervous system, and at the sides of the body. In a full-grown larva of *Corydalus cornuta* the adipose tissue is often greater in bulk than all of the other organs found inside of the muscular walls of the body. In adult insects it usually exists in much less quantity than in larvæ.

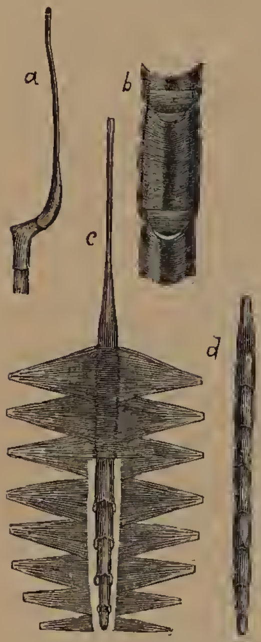

Fig. 69. — Heart of May-beetle (after Straus-Durckheim): *a*, lateral aspect of aorta; *b*, interior of heart showing valves; *c*, ventral aspect of heart and wing-muscles — the muscles are represented as cut away from the caudal part of the heart; *d*, dorsal aspect of heart.

The circulatory system. — In insects the circulatory system is not a closed one, the blood flowing in vessels during only a part of its course. The greater part of the circulation of this fluid takes place in the cavities of the body and of its appendages, where it fills the space not occupied by the internal organs.

Almost the only blood-vessel that exists in insects lies just beneath the body-wall, above the alimentary canal (Fig. 67, *h*). It extends from near the caudal end of the abdomen through the thorax into the head. That part of it that lies in the abdomen is the *heart;* the more slender portion, which traverses the thorax and extends into the head is the *aorta.*

On each side of the heart, there is a series of triangular muscles extending from the heart to the lateral wall of the body. These constitute the *dorsal diaphragm* or the *wings of the heart.*

The heart is a tube, which is usually closed at its posterior end; at its anterior end it is continuous with the aorta. The heart is divided into chambers (Fig. 69). The number of these chambers varies greatly in different insects; in some, there is only one, in others, as in the cockroach, there are as many as thirteen, but usually there are not more than eight. The blood is admitted to the heart through slit-like openings, the *ostia of the heart;* usually there is a pair of ostia in the lateral walls of each chamber. Each ostium is furnished with a valve-like structure which closes it when the chamber contracts.

When a heart consists of several chambers, they contract one after another, the wave of contraction passing from the caudal end of the heart forwards. As the valves between the chambers permit the blood to move forward but not in the opposite direction, the successive contractions of the chambers cause the blood received through the ostia to flow toward the head, into the aorta. The blood flows from the open, cephalic end of the aorta and passes in quite definite streams to the various parts of the body-cavity and into the cavities of the appendages. These streams, like the ocean currents, have no walls but flow in the spaces between the internal organs. After bathing these organs, the blood returns to the sides of the heart, which it enters through the ostia.

The blood consists of two elements, a fluid *plasma* and cells similar to the white corpuscles of the blood of vertebrates, the *leucocytes*. It differs greatly in appearance from the blood of vertebrates, on account of the absence of red blood corpuscles. In most insects the blood plasma is colorless; but in many species it has a yellowish, greenish, or reddish color.

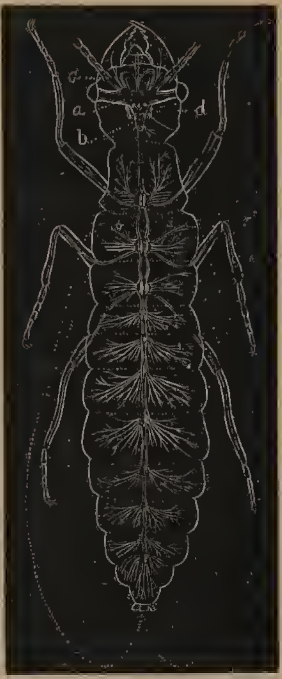

Fig. 70. — Nervous system of *Corydalus*. (After Leidy.)

The blood receives the products of digestion of food, which pass in a liquid form, by osmosis, through the walls of the alimentary canal. On the other hand it gives up to the tissues which it bathes the materials needed for their growth. In insects oxygen is supplied to the tissues and gaseous wastes are removed chiefly by the respiratory system and not by means of the blood as in vertebrates.

The nervous system. — The central part of the nervous system, as already indicated, consists of a ganglion in the head above the œsophagus, and of a ganglia, typically one for each segment of the body, lying on the floor of the body cavity, and connected by two longitudinal cords. In the head, one of these cords passes on each side of the œsophagus, from the brain to another ganglion in the head below the œsophagus, thus forming a nervous collar about the alimentary canal. From each ganglion nerves arise, which supply the adjacent parts; and from the thoracic ganglia nerves extend to the legs and wings. This series of ganglia is really a double one; but the members of each pair of ganglia are more or less closely united on the middle line of the body, and often appear as a single ganglion. Figure 70 gives a general view of the central nervous system of *Corydalus cornuta*.

In addition to the central nervous system there are two sympathetic nervous systems and the peripheral sensory nervous system, the latter composed of a network of fine nerves all around the body just beneath the hypodermis of the body walls.

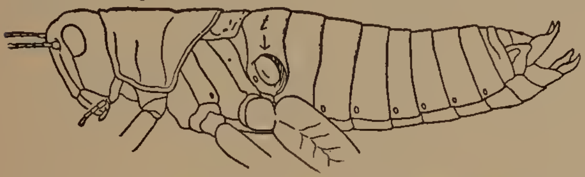

Fig. 71. — Side-view of locust with wings removed.

How insects breathe — The respiratory system. — A common mistake made by beginners in the study of Entomology is to suppose that insects breathe through the mouth as do the higher animals. Many a beginner has carefully poured chloroform on the head of an insect in the expectation of killing it in that way, and has been surprised at his poor success.

The truth is, insects breathe through their sides. If an insect be carefully examined, there can be found along the sides of the body a series of openings (Fig. 71). These are the openings through which the air passes into the respiratory system and are termed *spiracles*.

The number of spiracles varies greatly in different insects. There is, however, never more than one pair on a single segment of the body. They do not occur on the head, but are borne by each of the last two thoracic segments, and by the first eight abdominal segments. Thus ten segments may bear spiracles, but usually one or more segments lack them.

These spiracles are either simple openings into the respiratory system, or are provided with valves, sieves, or fringes of hair for the exclusion of dirt. They lead into a system of air-tubes termed *tracheæ*. The accompanying figure will indicate the distribution of the main trunks of these tracheæ in a cockroach (Fig. 72). There is a short trunk arising from each spiracle; these are all connected together by a large longitudinal trunk on each side of the body, and by numerous transverse trunks. From these large tracheæ there arise a great number of smaller ones, not shown in the figure, which branch and subdivide and extend to all parts of the body. Connected to the tips and sides of these small tracheæ are minute tubes called *tracheoles*. The tracheoles appear to be ultimately connected with the various tissues and it is through these that air reaches the tissues of the body.

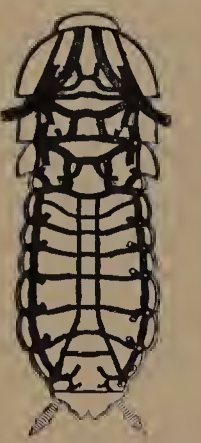

FIG. 72. — Tracheal system of cockroach. The alimentary canal removed to show the ventral tracheal communications. (After Miall and Denny.)

Although insects are, strictly speaking, air-breathing animals, many of them, as is well known, live in the water. The study of the ways in which aquatic insects breathe is a very interesting one; it presents to us many wonderful modifications of structure. Some of the more common of these are described in subsequent pages of this book; in this place we can only make a few generalizations.

The various modes of respiration of aquatic insects may be classified under two heads: first, those in which the insects obtain air from above the surface of the water; second, those in which the insects breathe the air that is mechanically mixed with the water.

With many aquatic insects the spiracles open beneath the wings, which are folded upon the abdomen. The insect, by coming to the surface of the water and lifting the tips of its wings, forms a cavity beneath them, into which the air rushes. The insect can then swim through the water, carrying this air with it in a position where it can be respired. When the air becomes impure, the insect rises to the surface, forces out the air from beneath its wings, and takes in a new supply. Water beetles and aquatic bugs afford familiar examples of this mode of respiration.

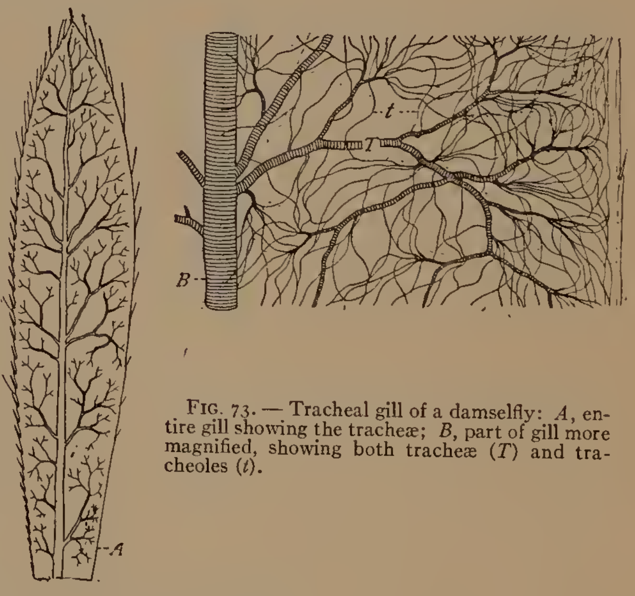

FIG. 73. — Tracheal gill of a damselfly: *A*, entire gill showing the tracheæ; *B*, part of gill more magnified, showing both tracheæ (*T*) and tracheoles (*t*).

Some insects are provided with long tubes connected with their spiracles, by means of which they can draw their supply of air from above the surface of the water while they crawl upon the bottom of shallow ponds. Our most common illustrations of this are bugs of the family *Nepidæ;* but the most remarkable development of this kind is exhibited by certain dipterous larvæ of the family *Syrphidæ*, known as rat-tailed maggots.

Although there are many insects that live in the water and draw their supply of air from above it, many aquatic insects breathe, as do fishes, the air that is mixed with the water. This is accomplished by organs known as *tracheal gills*. These are hair-like or more or less plate-like expansions of the body-wall, abundantly supplied with tracheæ (Fig. 73). These tracheæ divide and subdivide, and their terminations or fine branches, tracheoles, are separated from the water that bathes the organ only by its thin walls. In this way the air contained in the tracheæ is separated from the air in the water only by a delicate membrane, which admits of the transfer of gases between them. It will be observed that the difference between a tracheal gill and a true gill (as of fishes, crustacea, etc.) is that the true gill is supplied with vessels containing *blood*, which is purified by being brought in contact with the air in the water, while the tracheal gill is supplied with tracheæ containing *air* to be purified.

Tracheal gills are usually borne by the abdomen, sometimes by the thorax, and in case of some stoneflies by the head. They pertain almost exclusively to the immature stages of insects; but stoneflies of the genus *Pteronarcys* retain them throughout their existence.

Tracheal gills vary greatly in form; in *Corydalus* they are hair-like, and occur in tufts near the lateral margins of the abdominal segments; in the caddice-worms they are thread-like, more or less branched, and irregularly distributed over the surface of the abdomen; and in certain damselflies they are in the form of large plate-like caudal appendages. (Fig. 73.)

The reproductive organs. — The reproductive organs are situated in the abdomen, as represented in Figure 67. There is a set on each side of the body; but the two sets usually open by a common tube near the caudal end of the body. In the mayflies and in the earwigs, however, the reproductive organs of each side have a distinct opening. Thus mayflies are often found with two bunches of eggs projecting from the caudal end of the body.

All insects are developed from eggs; but there are some apparent exceptions. Thus many flies retain their eggs until after they are hatched, and in some flies the young attain a considerable development before they are born. In the plant-lice (*Aphididæ*) there is a remarkable alternation of reproduction. This is described more fully in the account of that family.

THE SUBCLASSES AND ORDERS OF THE HEXAPODA

The class, Hexapoda, is divided into two subclasses, the *Apterygota* and the *Pterygota*. The primitive insects were undoubtedly wingless; and there are two orders of living insects, the *Thysanura* and the *Collembola*, which are still wingless. These orders constitute the subclass Apterygota. All other insects are believed to have descended from winged ancestors and are therefore placed in the subclass, Pterygota. Some of the forms in this subclass, for example the bird-lice, the sucking lice and the fleas have lost their wings during their sedentary parasitic lives but this wingless condition is certainly an acquired one.

We have divided the Hexapoda in this work into twenty-five orders and have arranged them in a linear series as must be done in a simple text-book; for it is impossible to indicate in a satisfactory way either the relation of the orders to each other or the relative rank of the orders. An effort is made to place near together closely allied orders, and to treat first those that are more simple or primitive or generalized in structure, and last those that are more specialized. But this plan could be fully carried out only by having several parallel columns on the pages of the book, each representing a distinct line of descent, an arrangement which, to say the least, is impracticable.

The list below indicates the sequence in which the orders are discussed in the following chapters.

SUBCLASS APTERYGOTA. — Wingless insects in which the wingless condition is believed to be a primitive one, there being no indication that they have descended from winged ancestors.

1. ORDER THYSANURA. — The Bristle-tails. p. 45
2. ORDER COLLEMBOLA. — The Spring-tails. p. 47

SUBCLASS PTERYGOTA. — Winged insects and wingless insects in which the wingless condition is believed to be an acquired one; *i.e.*, those insects that have descended from winged ancestors.

3. ORDER ORTHOPTERA. — The Cockroaches, Crickets, Grasshoppers, and others. p. 49
4. ORDER ZORAPTERA. — The genus *Zorotypus*. p. 62
5. ORDER ISOPTERA. — The Termites or White Ants. p. 63
6. ORDER NEUROPTERA. — The Dobson, Aphis-lions, Ant-lions, and others. p. 66
7. ORDER EPHEMERIDA. — The Mayflies. p. 74
8. ORDER ODONATA. — The Dragonflies and the Damselflies. p. 77
9. ORDER PLECOPTERA. — The Stoneflies. p. 81
10. ORDER CORRODENTIA. — The Psocids. p. 83
11. ORDER MALLOPHAGA. The Bird-lice. p. 85
12. ORDER EMBIIDINA. — The Embiids. p. 87
13. ORDER THYSANOPTERA. — The Thrips. p. 89
14. ORDER ANOPLURA. — The Lice. p. 92
15. ORDER HEMIPTERA. — The True Bugs. p. 94
16. ORDER HOMOPTERA. — The Cicadas, Leafhoppers, Aphids, Scale-bugs, and others. p. 109
17. ORDER DERMAPTERA. — The Earwigs. p. 125
18. ORDER COLEOPTERA. — The Beetles. p. 127
19. ORDER STREPSIPTERA. — The Twisted Winged Insects. p. 176
20. ORDER MECOPTERA. — The Scorpion-flies. p. 178
21. ORDER TRICHOPTERA. — The Caddice-flies. p. 180
22. ORDER LEPIDOPTERA. — The Moths, the Skippers, and the Butterflies. p. 183
23. ORDER DIPTERA. — The Flies. p. 286
24. ORDER SIPHONAPTERA. — The Fleas. p. 326
25. ORDER HYMENOPTERA. — The Bees, Wasps, Ants, and others. p. 329

TABLE FOR DETERMINING THE ORDERS OF THE HEXAPODA

This table is merely intended to aid the students in determining to which of the orders a specimen that he is examining belongs. No effort has been made to indicate in the table the relation of the orders to one another.

A. Winged. (The wing-covers, *Elytra*, of beetles and of earwigs are wings.)
  B. With two wings.
    C. Wings horny, leathery, or parchment-like.
      D. Mouth-parts formed for sucking. Wings leathery, shortened, or membranous at the tip. p. 94 .... HEMIPTERA
      DD. Mouth-parts formed for biting. Jaws distinct.

E. Wings horny, without veins. Hind legs not fitted for jumping. p. 127 .... Coleoptera
EE. Wings parchment-like with a network of veins. Hind legs fitted for jumping. p. 49 .... Orthoptera
CC. Wings membranous.
D. Abdomen with caudal filaments. Mouth-parts vestigial.
E. Halteres wanting. p. 74 .... Ephemerida
EE. Halteres present (males of Coccidæ). p. 109 .... Homoptera
DD. Abdomen without caudal filaments. Halteres in place of second wings. Mouth-parts formed for sucking. p. 286 .... Diptera
BB. With four wings.
C. The two pairs of wings unlike in structure.
D. Fore wings reduced to slender club-shaped appendages; hind wings fan-shaped with radiating veins. Minute insects. p. 176 .... Strepsiptera
DD. Front wings leathery at base, and membranous at tip, often overlapping. Mouth-parts formed for sucking. p. 94 .... Hemiptera
DDD. Front wings of same texture throughout.
E. Front wings horny or leathery, being veinless wing-covers. (*Elytra.*)
F. Abdomen with caudal appendages in form of movable forceps. p. 125 .... Dermaptera
FF. Abdomen without forceps-like appendages. p. 127 .... Coleoptera
EE. Front wings leathery or parchment-like with a network of veins.
F. Under wings not folded; mouth-parts formed for sucking.
G. Beak arising from the front part of the head. p. 94 .... Hemiptera
GG. Beak arising from the hind part of the lower side of the head. p. 109 .... Homoptera
FF. Under wings folded lengthwise. Mouth-parts formed for chewing. p. 49 .... Orthoptera
CC. The two pairs of wings similar, membranous.
D. Last joint of tarsi bladder-like or hoof-like in form and without claws. Wings with fringe of long hairs. p. 89 .... Thysanoptera
DD. Last joint of tarsi not bladder-like.
E. Wings entirely or for the greater part clothed with scales. Mouth-parts formed for sucking. p. 183 .... Lepidoptera
EE. Wings naked, transparent, or thinly clothed with hairs.
F. Mouth-parts arising from the hinder part of the lower surface of the head, and consisting of bristle-like organs inclosed in a jointed sheath. p. 109 .... Homoptera
FF. Mouth-parts in normal position. Mandibles not bristle-like.
G. Wings net-veined, with many veins and cross-veins.
H. Tarsi consisting of less than five segments.
I. Antennæ inconspicuous, awl-shaped, short and slender.
J. First and second pairs of wings of nearly the same length; tarsi three-jointed. p. 77 .... Odonata
JJ. Second pair of wings either small or wanting; tarsi four-jointed. p. 74 .... Ephemerida
II. Antennæ usually conspicuous, setiform, filiform, clavate, capitate, or pectinate.
J. Tarsi two- or three-jointed.
K. Second pair of wings the smaller. p. 83 .... Corrodentia
KK. Second pair of wings broader, or at least the same size as the first pair. p. 81 .... Plecoptera
JJ. Tarsi four-jointed; wings equal. p. 63 .... Isoptera
HH. Tarsi consisting of five segments.
I. Abdomen with setiform, many-jointed anal filaments. (Certain mayflies). p. 74 .... Ephemerida
II. Abdomen without many-jointed anal filaments.
J. Head prolonged into a trunk-like beak. p. 178 .... Mecoptera
JJ. Head not prolonged into a beak. p. 66 .... Neuroptera
GG. Wings with branching veins and comparatively few cross-veins, or veinless.
H. Each of the veins of the wing extending along the middle of a brown line. p. 87 .... Embiidina
HH. Wings not marked with brown lines.

- I. Tarsi two- or three-jointed.
  - J. Hind wings smaller than the fore wings.
    - K. Cerci present; body less than three millimeters in length. p. 62 .... ZORAPTERA
    - KK. Cerci absent; larger insects. p. 83 .... CORRODENTIA
  - JJ. Posterior wings as large as or larger than the anterior ones. (Certain stoneflies). p. 81 .... PLECOPTERA
- II. Tarsi four- or five-jointed.
  - J. Abdomen with setiform, many-jointed anal filaments (Certain mayflies). p. 74 .... EPHEMERIDA
  - JJ. Abdomen without many-jointed anal filaments.
    - K. Prothorax horny. First wings larger than the second, naked or imperceptibly hairy. Second wings without or with few, unusually simple, veins. Jaws (mandibles) well developed. Palpi small. p. 329.............. HYMENOPTERA
    - KK. Prothorax membranous or, at the most, parchment-like. Second wings as large as or larger than the first, folded lengthwise, with many branching veins. First wings naked or thinly clothed with hair. Jaws (mandibles) inconspicuous. Palpi long. Moth-like insects. p. 180 .... TRICHOPTERA

- AA. Wingless or with vestigial or rudimentary wings.
  - B. Insects with a distinct head and jointed legs, and capable of locomotion.
    - C. Aquatic insects.
      - D. Mouth-parts fitted for piercing and sucking.
        - E. Free-swimming nymphs. p. 94 .... HEMIPTERA
        - EE. Larvæ parasitic in sponges (Sisyridæ). p. 66 .... NEUROPTERA
      - DD. Mouth-parts fitted for chewing.
        - E. Either somewhat caterpillar-like larvæ that live in portable cases or campodeiform larvæ that spin nets for catching their food. (Caddice-worms). p. 180.. TRICHOPTERA
        - EE. Neither case-bearing nor net-spinning larvæ.
          - F. Naiads, that is, immature insects that resemble adults in having the thorax sharply differentiated from the abdomen, and, except in very young individuals, with rudimentary wings.
            - G. Lower lip greatly elongated, jointed, capable of being thrust forward, and armed at its extremity with sharp hooks. p. 77 .... ODONATA
            - GG. Lower lip not capable of being thrust forward.
              - H. Usually with filamentous tracheal gills on the ventral side of the thorax. p. 81 .... PLECOPTERA
              - HH. Tracheal gills borne by the first seven abdominal segments. p. 74 .... EPHEMERIDA
          - FF. Larvæ, that is, immature forms that do not resemble adults in the form of the body, and in which the developing wings are not visible externally.
            - G. Several segments of the abdomen furnished with prolegs. p. 183 .... LEPIDOPTERA
            - GG. With only anal prolegs or with none.
              - H. With paired lateral filaments on most or on all of the abdominal segments. (Sialidæ). p. 66 .... NEUROPTERA
                See also Haliplidæ and Gyrinidæ. p. 127............ COLEOPTERA
              - HH. Without paired lateral filaments on the abdomen. p. 127 .... COLEOPTERA
    - CC. Terrestrial insects.
      - D. External parasites.
        - E. Infesting the honey-bee. (*Braula*). p. 286...................... DIPTERA
        - EE. Infesting birds or mammals.
          - F. Body strongly compressed. (Fleas). p. 326.............. SIPHONAPTERA
          - FF. Body not strongly compressed.
            - G. Mouth-parts formed for chewing. (Bird-lice). p. 85 ... MALLOPHAGA
            - GG. Mouth-parts formed for piercing and sucking.
              - H. Antennæ inserted in pits, not visible from above. (Pupipara). p. 286 .... DIPTERA
              - HH. Antennæ exserted, visible from above.

I. Tarsi with a single claw which is opposed by a toothed projection of the tibia. (Lice). p. 92 .... Anoplura

II. Tarsi two-clawed. p. 94 .... Hemiptera

DD. Terrestrial insects not parasites.

E. Mouth-parts apparently retracted within the cavity of the head so that only their apices are visible, being overgrown by folds of the genæ.

F. Abdomen consisting of ten or eleven segments. (Campodeidæ and Japygidæ). p. 45 .... Thysanura

FF. Abdomen consisting of not more than six segments. p. 47 .... Collembola

EE. Mouth-parts mandibulate, either fitted for chewing or with sickle-shaped mandibles formed for seizing prey. (See also EEE.)

F. Larvæ with abdominal prolegs.

G. Prolegs armed at the extremity with numerous minute hooks. (Caterpillars). p. 183 .... Lepidoptera

GG. Prolegs not armed with minute hooks.

H. With a pair of ocelli, one on each side. (Larvæ of saw-flies). p. 329 .... Hymenoptera

HH. With many ocelli on each side of the head. p. 178 .. Mecoptera

FF. Without abdominal prolegs.

G. Body clothed with scales. (Machilidæ and Lepismatidæ). p. 45 .... Thysanura

GG. Body not clothed with scales.

H. Antennæ long and distinct.

I. Abdomen terminated by strong movable forceps. p. 125 .... Dermaptera

II. Abdomen not terminated by forceps.

J. Abdomen strongly constricted at base. (Ants, etc.) p. 329 .... Hymenoptera

JJ. Abdomen not strongly constricted at base.

K. Head with a long trunk-like beak. (*Boreus*). p. 178 .... Mecoptera

KK. Head not prolonged into a trunk.

L. Insects of small size, more or less louse-like in form, with a very small prothorax, and without cerci. (Book-lice and Psocids). p. 83 .... Corrodentia

LL. Insects of various forms, but not louse-like, prothorax not extremely small; cerci present.

M. Hind legs fitted for jumping, hind femora enlarged. (Wingless locusts, grasshoppers, and crickets). p. 49 .... Orthoptera

MM. Hind femora not greatly enlarged, not fitted for jumping.

N. Prothorax much longer than the mesothorax; front legs fitted for grasping prey. (Mantidæ). p. 49 .... Orthoptera

NN. Prothorax not greatly lengthened.

O. Cerci present; antennæ usually with more than fifteen joints, often many-jointed.

P. Cerci with more than three joints.

Q. Body flattened and oval. (Blattidæ). p. 49 .... Orthoptera

QQ. Body elongate.

R. Head very large. (*Termopsis*). p. 63 .... Isoptera

RR. Head of moderate size. p. 49 .... Orthoptera

PP. Cerci short, with one to three joints.

Q. Body linear with very long linear legs. (Walking-sticks). p. 49 .... Orthoptera

QQ. Body elongate or not, if elongate the legs are not linear.

R. Body elongate; front tarsi with first joint swollen. p. 87 .... Embiidina

RR. Front tarsi not enlarged.

S. Minute insects, less than $\frac{1}{8}$ of an inch in length; antennæ nine-jointed. p. 62 .... Zoraptera

SS. Larger insects; antennæ usually more than nine-jointed. (White-ants). p. 63 .... Isoptera

OO. Cerci absent; antennæ usually with eleven joints. p. 127 .... Coleoptera

HH. Antennæ short, not pronounced; larval forms.

I. Body cylindrical, caterpillar-like. p. 178 .... Mecoptera

II. Body not caterpillar-like.

J. Mandibles sickle-shaped; each mandible with a furrow over which the maxilla of that side fits, the two forming an organ for piercing and sucking. (Ant-lions, aphislions, hemerobiids). p. 66 .... Neuroptera

JJ. Mouth-parts not of the ant-lion type.

K. Larva of *Raphidia*. p. 66 .... Neuroptera

KK. Larvæ of beetles. p. 127 .... Coleoptera

EEE. Mouth-parts haustellate, fitted for sucking; mandibles not sickle-shaped.

F. Body covered with a waxy powder or with tufts or plates of wax. (Mealy-bugs, *Orthezia*). p. 94 .... Hemiptera

FF. Body more or less covered with minute scales, or with thick long hairs; proboscis if present coiled beneath the head. (Moths). p. 183 .... Lepidoptera

FFF. Body naked, or with isolated or bristle-like hairs.

G. Prothorax not well developed, inconspicuous or invisible from above. p. 286 .... Diptera

GG. Prothorax well developed.

H. Last joint of tarsi bladder-like or hoof-like in form and usually without claws; mouth-parts forming a triangular unjointed beak. p. 89 .... Thysanoptera

HH. Last joint of tarsi not bladder-like, and furnished with one or two claws; mouth-parts forming a slender, usually jointed beak.

I. Beak arising from the front part of the head. p. 94. Hemiptera

II. Beak arising from the back part of the head. p. 109. Homoptera

BB. Either without a distinct head, or without jointed legs, or incapable of locomotion.

C. Forms that are legless but capable of locomotion; in some the head is distinct, in others not. Here belong many larvæ representing several of the orders, and the active pupæ of mosquitoes and certain midges. It is impracticable to separate them in this key.

CC. Sedentary forms, incapable of locomotion.

D. Small abnormal insects in which the body is either scale-like or gall-like in form, or grub-like clothed with wax. The waxy covering may be in the form of powder, or large tufts or plates, or a continuous layer, or of a thin scale, beneath which the insect lives. (Coccidæ). p. 94 Hemiptera

DD. Pupæ, the inactive stage of insects with a complete metamorphosis; capable only of a wriggling motion, and incapable of feeding.

E. Obtected pupæ, pupæ in which the legs and wings are glued to the surface of the body; either in a cocoon or naked. p. 183.... Lepidoptera

EE. Coarctate pupæ, pupæ enclosed in the hardened larval skin. p. 286 .... Diptera

EEE. Exarate pupæ, pupæ that have the legs and wings free; either in a cocoon or naked. This type of pupa is characteristic of all of the orders in which the metamorphosis is complete except the Lepidoptera and Diptera.

CHAPTER III

ORDER THYSANURA *

The Bristle-tails

The members of this order are wingless insects still in a primitive condition. The mouth-parts are formed for chewing and the adults resemble the young in form for they do not have marked metamorphosis. The segments of the abdomen are of the usual number, eleven, and the last one usually bears two or three long, segmented, filiform appendages.

The members of this order are known as bristle-tails, a name suggested by the presence, in most of them, of either two or three many-jointed filiform appendages at the caudal end of the body (Fig. 74). The paired caudal appendages are the cerci; the median one, when three are present, is the median caudal filament, a prolongation of the eleventh abdominal segment.

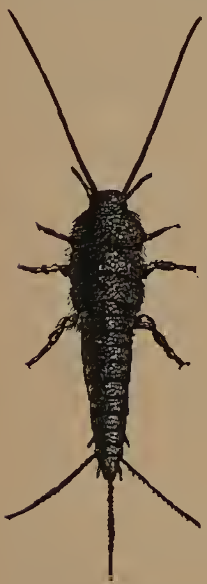

Fig. 74. — *Lepisma saccharina.* (After Lubbock.)

The bristle-tails are most often found under stones and other objects lying on the ground; but some species live in houses. While most species prefer cool situations, there is one, the fire-brat, that frequents warm ones, about fire-places and in bakehouses. The antennæ are long and many-segmented. There are less than twenty species known in this country.

In one family the compound eyes are very perfect but in all others they are more or less degenerate or are lost entirely.

The mouth-parts are formed for chewing but in many of the forms the jaws are apparently sunk in the head due to being overgrown by folds of the cheeks, or genæ. In two families the jaws are not overgrown and the mouth-parts project in a normal manner.

An interesting feature of some members of this order is the short, slender, two-segmented appendages found on the ventral side of the abdomen and known as *styli*. The styli are believed to be vestiges of legs persisting from many-legged ancestors probably centipede-like animals, the symphylids (See, An Introduction to Entomology, p. 23.)

A common representative of this order is the fish-moth or silver-fish (*Lepĭsma saccharīna*) as it is variously called.

Often the careful housekeeper sees in the ironing-basket, or upon the book-shelf where she is dusting, a flash of light like a tiny thread of quicksilver, that usually vanishes as soon as seen.

If she is experienced she knows that this streak of light is a little animal, half an inch long, whose body is clothed in shining scales like those of a fish. Hence she calls it a fish-moth. It is especially abundant in warm climates, and often does damage to starched clothing, bookbindings, and sometimes loosens wall-paper by eating out the paste. Under a microscope the fish-moth shows beautiful markings on the shining scales; and at the caudal end of the body are three long bristle-like appendages (Fig. 74), which suggest the common name bristle-tail applied to members of this suborder.

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* Thysanūra: *thysanos* (θύσανος), a tassel; *oura* (οὐρά), the tail.

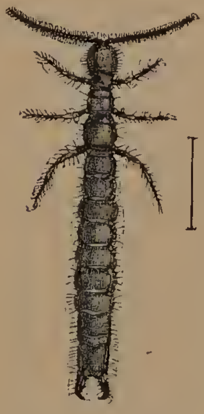

FIG. 75. — *Japyx* (After Lubbock.)

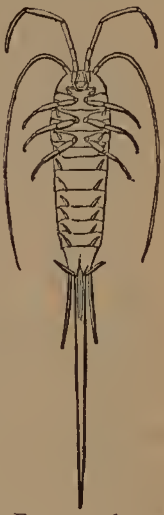

FIG. 76. — Ventral aspect of *Machilis*, showing appendages.

Another common form is the fire-brat (*Thermōbia domĕstica*), which resembles the fish-moth in general appearance. It is remarkable for frequenting warm, even hot places, about ovens, ranges, and fire-places.

Figure 75 represents *Jāpyx*, a bristle-tail in which the caudal appendages are in the form of horny forceps; and Figure 76 represents the lower side of *Măchilis*, another bristle-tail found under stones and bark. This is the form that has vestigial legs on the abdomen.

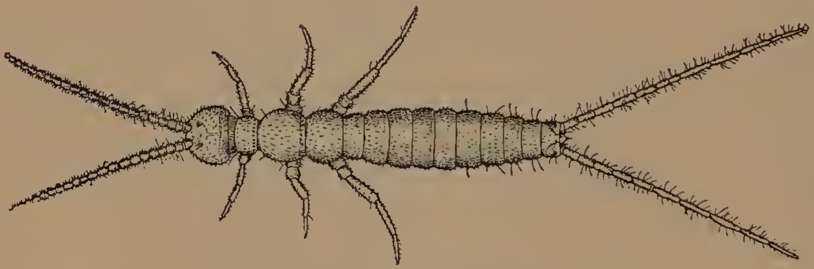

FIG. 76a. — *Campodea staphylinus.*

An illustration of a small, delicate, whitish thysanuran, *Campodea staphylinus*, which lives in damp places under stones or in rotten wood and leaves. Note that the thorax and abdomen differ from each other very little in form. This is true of many of these simple insects. (After Lubbock.)

CHAPTER IV

ORDER COLLEMBOLA *

The Spring-tails

The insects of this order are wingless insects still in a primitive condition. The mouth-parts are formed either for chewing or for sucking. The adults resemble the young in form for they do not have a marked metamorphosis. The segments of the abdomen are reduced to six in number. On the ventral side of the abdomen in many species is a springing organ.

The spring-tails are minute insects, often of microscopic size and rarely more than 1/5 of an inch in length. Most of the species live on decaying matter. They are common under stones and decayed leaves and wood, in the chinks and crevices of bark, among moss, and on herbage in damp places. Sometimes they occur abundantly in winter on the surface of snow where they appear as minute black specks which spring away at our feet on either side. Some species collect in great numbers on the surface of standing pools of water.

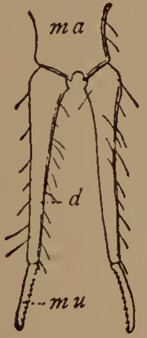

FIG. 77. — The "spring" of *Papirius: ma*, manubrium; *d*, left dens; *mu*, left mucrone. (After Lubbock.)

There is, on the underside of the fourth abdominal segment of most of these insects a fork-like appendage, the springing organ (Fig. 77), which, when the insect is at rest, is bent forward beneath the body and caught and held under tension by a catch on the third segment. When this organ is released it suddenly springs backward and throws the insect high in the air several feet away. This action is like a spring-board jump, only these tiny insects always carry their spring-boards with them, and thus have won the name of spring-tails.

Typically, the mouth-parts of the spring-tails are chewing with the jaws overgrown by the cheeks until they are hardly visible. In a few forms the mandibles and maxillæ have become modified into needle-like organs which are used for piercing and sucking.

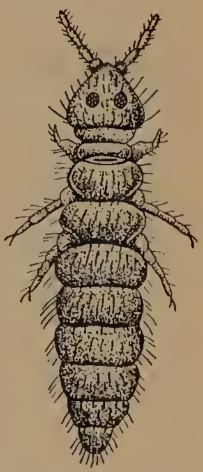

FIG. 78. — The snow-flea, *Achorutes nivicola*. (After Folsom.)

These insects possess a peculiar organ called the *ventral tube*, or *collophore*. It may be wart-like or tube-like in form and it is situated on the underside of the first abdominal segment. It exudes a viscid fluid by means of which the insects are enabled to cling to the lower surface of an object.

A common species of spring-tail is the snow-flea, *Achorūtes nivĭcola* (Fig. 78), which occurs abundantly in winter on the surface of the snow.

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* Collĕmbola: *colla* (κόλλα), glue; *embolon* (ἔμβολον), a bolt, bar; — from their collophores.

It sometimes proves a nuisance in sugar-bushes by getting into the sap.

Another tiny one, the garden-flea, *Sminthūrus hortĕnsis*, often becomes a pest by feeding on young cabbages, turnips, cucumbers, and squashes.

Through a microscope, certain spring-tails appear very absurd. They have long antennæ and large dark eye-spots on the face, which, together with the long hair that sticks forward on the head and thorax, give the creature a look of solemn fierceness (Fig. 79). Different species may be found at almost any time of the year in damp places.

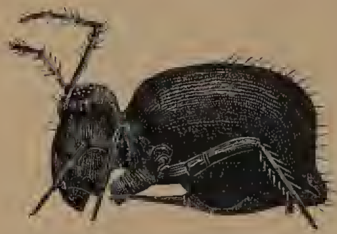

FIG. 79. — *Papirius fuscus.* (After Lubbock.)

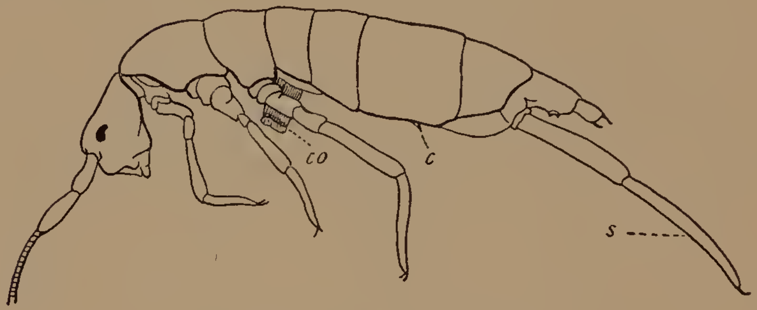

FIG. 79a. — *Tomocerus plumbens,*

A side view of a spring-tail, *Tomocerus plumbens*, showing that curious organ, the *collophore*, *co*; and the *catch*, *c*, which holds the *spring*, *s*, in place and under tension when the latter is drawn beneath the abdomen.

CHAPTER V

ORDER ORTHOPTERA[*]

Grasshoppers, Crickets, Cockroaches, and others

The winged members of this order have two pairs of wings; the fore wings are more or less thickened, but have a distinct venation; the hind wings are folded in plaits like a fan when at rest; there are many forms in which the wings are vestigial or even wanting. The mouth-parts are formed for chewing. The metamorphosis is incomplete; the nymphs are terrestrial.

The order Orthoptera includes some of the very common and best-known insects. The most familiar representatives are those named above.

Although the song of the katydid and the chirp of crickets are most often associated with recollections of pleasant evenings spent in the country, we cannot forget that to members of this order are due some of the most terrible insect scourges man has known. The devastations caused by great swarms of migratory locusts are not only matters of historical record, but are too painfully known to many of our own generation in the western states.

With the exception of a single family (*Mantidæ*), the members of this order are, as a rule, injurious to vegetation; and many species are quite apt to multiply to such an extent that their destruction of vegetation becomes serious.

In the Orthoptera the two pairs of wings differ in structure. The fore wings are parchment-like, forming covers for the more delicate hind wings. These wing-covers have received the special name *tegmina;* they are furnished with a fine network of veins, and overlap at the tip at least. There are many species in which the wings are rudimentary, even in the adult state. Such adults resemble nymphs; but in the case of the jumping Orthoptera, where this peculiarity most often occurs, nymphs can be distinguished by the fact that the rudimentary hind wings are outside of the fore wings, instead of beneath them, as in the adult state.

There are six families of well-known insects in the order Orthoptera which can be separated by the following table.

A. Hind femora fitted for jumping, *i.e.*, very much stouter or very much longer, or both stouter and longer, than the middle femora; organs of flight of immature forms inverted; stridulating insects. (The SALTATORIAL ORTHOPTERA.)
  B. Antennæ long and setaceous, except in the mole-crickets and sand-crickets; tarsi three- or four-jointed; organs of hearing situated in the fore tibiæ; ovipositor elongate, except in the mole-crickets and sand-crickets, with its parts compact.
    C. Tarsi four-jointed; ovipositor, when exserted, forming a strongly compressed, generally sword-shaped blade. p. 50 .... TETTIGONIIDÆ

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[*] Orthŏptera: *orthos* (ὀρθός), straight; *pteron* (πτερόν), a wing.

CC. Tarsi usually three-jointed, except in the pigmy mole-crickets where they are reduced; ovipositor, when exserted, forming a nearly cylindrical, straight, or occasionally upcurved needle, except in the Trigonidiinæ. p. 53 . . . Gryllidæ
BB. Antennæ short; tarsi three-jointed; organs of hearing situated in the first abdominal segment; ovipositor short, with its parts separate. p. 56 . . . . Locustidæ
AA. Hind femora closely resembling those of the other legs, and scarcely if at all stouter or longer than the other femora, *i.e.*, not fitted for jumping; organs of flight in a normal position when immature; stridulating organs not developed.
B. Body elongate; head free; pronotum elongate; legs slender, rounded; cerci jointed or without joints; walking insects.
C. Front legs simple; cerci without joints. p. 58 . . . . Phasmidæ
CC. Front legs fitted for grasping; cerci jointed. p. 59 . . . . Mantidæ
BB. Body oval, depressed; head wholly or almost wholly withdrawn beneath the pronotum; pronotum shield-like, transverse; legs compressed; cerci jointed; rapidly running insects. p. 60 . . . . Blattidæ

Family Tettigoniidæ

The Long-horned Grasshoppers

This family has usually been given the name Locustidæ, but this name should be used for the family of short-horned grasshoppers or locusts. The members of this family are among the most attractive in appearance of the Orthoptera. In many of them the wings are graceful in form and delicate in color, and the antennæ are exceedingly long and slender, looking more like ornaments than like organs of practical use. The tarsi are four-segmented and the ovipositor is sword-shaped.

These beautiful creatures are much less frequently seen than are the crickets and locusts because of their protective green color, which renders them inconspicuous in their haunts among foliage or on the blades of grass. Their presence is most often indicated by the chirping of the males.

Any one that is in the habit of lying in the tall grass of meadows or pastures and watching the insects that can be seen there is sure to be familiar with certain green grasshoppers, which attract attention by the extreme delicacy and great length of their antennæ. The antennæ are much more slender than with the short-horned grasshoppers or locusts, and much longer, exceeding the body in length. The tarsi are four-jointed. The ear-like organs, when present, are situated near the base of the fore tibiæ (Fig. 80), and the ovipositor is sword-shaped.

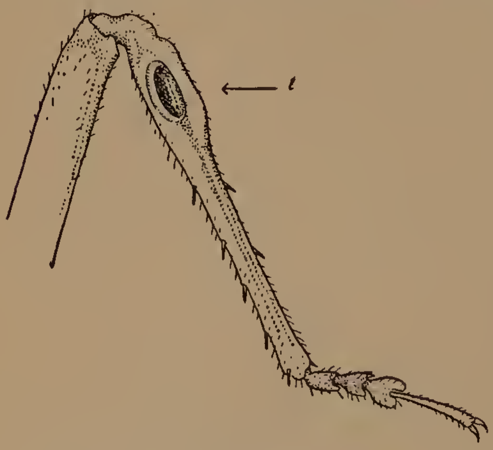

Fig. 80. — Leg of katydid, showing ear-like organ.

In those species of this family in which the wings are well developed we find the males provided with an elaborate musical apparatus by means of which they call their mates. This consists of a peculiar arrangement of the veins and cells of a portion of each wing-cover near its base. This arrangement differs in the different species; but in each it is such that by rubbing the wing-covers together they are made to vibrate, and thus produce the sound. Figure 81 represents a wing-cover of the male of a common meadow grasshopper, and Figure 82 that of a female of the same species.

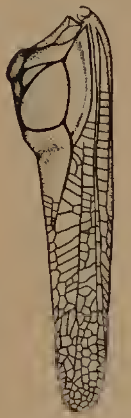

FIG. 81. — Wing-cover of male meadow grasshopper.

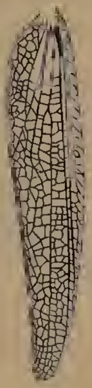

FIG. 82. — Wing-cover of female meadow grasshopper.

In order to facilitate the study of this family the more common representatives can be arranged in four groups; the katydids, the meadow grasshoppers, the cricket-like grasshoppers, and the shield-backed grasshoppers.

THE KATYDIDS

The chances are that he who lies awake of a midsummer night must listen whether he wishes to do so or not, to an oft-repeated, rasping song that says, "Katy did, Katy did; she did, she didn't," over and over again. There is no use of wondering what Katy did or didn't do, for no mortal will ever know. If, when the dawn comes, the listener has eyes sharp enough to discern one of these singers among the leaves of some neighboring tree, never a note of explanation will he get. The beautiful, finely-veined wings folded close over the body keep the secret hidden, and the long antennæ, looking like threads of living silk, will wave airily above the droll, green eyes as much as to say, "Wouldn't you like to know?" The katydids live among the branches of trees and the song made by the male is heard at night and occasionally on dark cloudy days. The true northern katydid, *Pterophylla camellifōlia*, is the species commonly known as the "Katydid" owing to its characteristic strident call. It is found throughout the United States east of the Rocky Mountains; but in the North it lives in colonies which occupy rather restricted areas (Fig. 83).

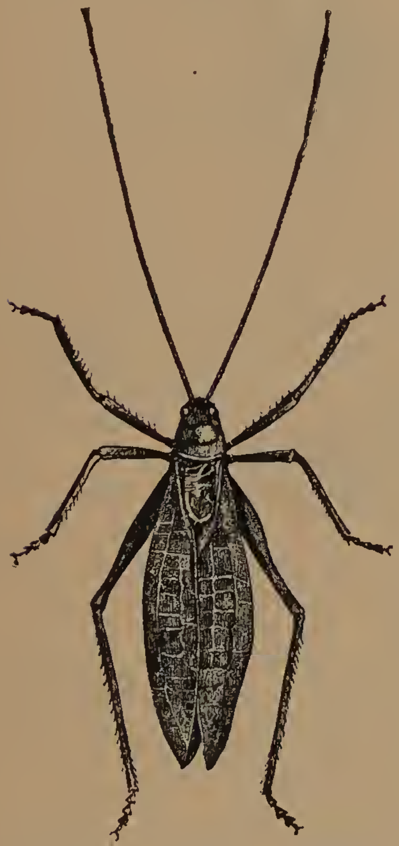

FIG. 83. — *Pterophylla camellifolia.* (After Harris.)

There are several species of false katydids with broad leaf-like wings that live in trees and look much like the real katydid. One of these is known as the angular-winged katydid, *Microcĕntrum rhombifŏlium.* It deposits its large elliptical eggs in rows along the edge of a leaf or on a small branch (Fig. 84).

There is another species of angular-winged katydid, *Microcĕntrum retinĕrve,* which is somewhat smaller than the preceding but closely resembles it in form and appearance.

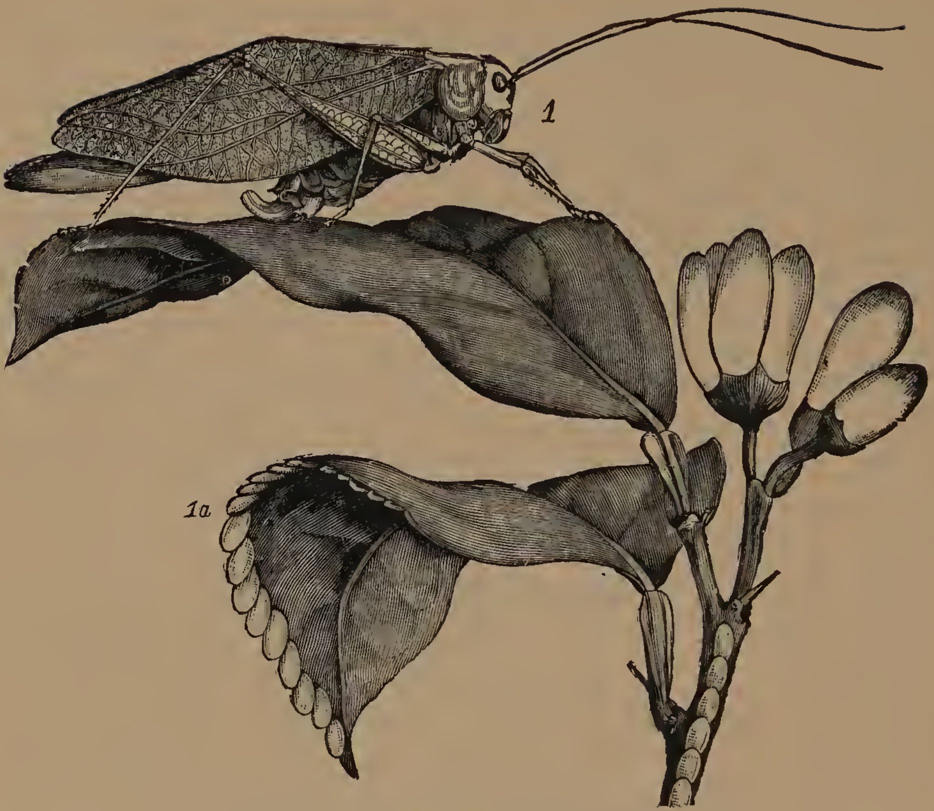

FIG. 84. — The angular-winged katydid and its eggs.

THE MEADOW GRASSHOPPERS

From the middle of the summer to the autumn there can be found upon the grass in our meadows and moist pastures many light-green long-horned grasshoppers of various sizes; these, on account of the situations in which they are usually found, are termed the *meadow grasshoppers*. They are of medium size and are the most common members of this family (Fig. 85). Associated with the meadow grasshoppers and living in the same situations, are often found larger, longer-winged grasshoppers with pointed heads, called the cone-headed grasshoppers.

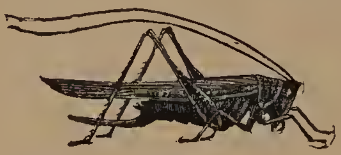

FIG. 85. — *Conocephalus.*

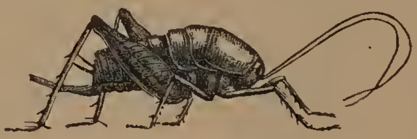

FIG. 86 — *Ceuthophilus.*

THE CRICKET-LIKE GRASSHOPPERS

These are the long-horned grasshoppers that bear some resemblance to the true crickets (Fig. 86). They have a short, thick body and remarkably stout hind femora, like a cricket, but are entirely destitute of tegmina and wings. The more common species are either of a pale brown or a dirty white color and more or less mottled with either lighter or darker shades.

These insects live in dark and moist places, under stones and rubbish, especially in woods, in cellars, in the walls of wells, and in caves. They are commonly called *cave-crickets* and some, because of the high arched back, *camel-crickets*.

THE SHIELD-BACKED GRASSHOPPERS

These are mostly wingless or nearly wingless, dull-colored insects which bear some resemblance to crickets. They present, however, a queer appearance, due to the pronotum extending backward over the rest of the thorax, like a sun-bonnet worn over the shoulders with the back side forward. These insects live in grassy fields or open woods. Most of them occur west of the Mississippi but a few of the genus *Atlănticus* occur in the East (Fig. 87). Some of the shield-backed grasshoppers of the genus *Anabrus*, popularly known as the *western cricket*, invade cultivated fields at times in the western states and destroy the crops.

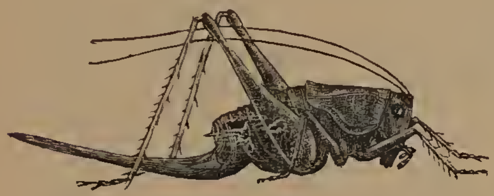

Fig. 87. — *Atlanticus.*

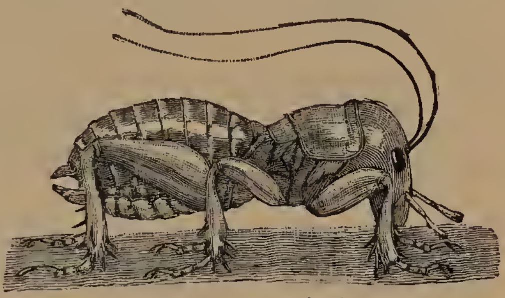

Fig. 88. — *Stenopelmatus.*

The *sand-crickets* of the Pacific Coast are not widely unrelated to the shield-backed grasshoppers. They are clumsy creatures with big heads that live under stones in loose soil. They belong to the genus, *Stenopelmātus* (Fig. 88).

Family GRYLLIDÆ

The Crickets

In the more typical crickets the hind legs are fitted for leaping and the antennæ are long and slender. The tegmina lie flat on the back and are bent down abruptly at the sides of the body like a box-cover. The ovipositor is spear-shaped and wings are absent in some species.

There are crickets, however, which have short antennæ, some in which the ovipositor is sword-shaped and a few without an ovipositor.

With most species of crickets the males differ greatly in appearance from the females. The males have musical organs which are even more elaborate than those of the katydids and meadow grasshoppers. Here all that part of each wing-cover that lies on the back is occupied by them. This gives the males a very different appearance from the females, the wing-covers of that sex being veined simply.

During the latter part of summer and in the autumn the air is filled with the chirping of crickets. It is an interesting thing to watch one of these fiddlers calling his mate. By moving quietly in the direction from which the sound comes, and stopping whenever the insect stops chirping, but moving on again when he renews his song, one can get near enough to see how he does it. This can be done even in the night with the aid of a lantern, as the crickets do not seem to mind lights.

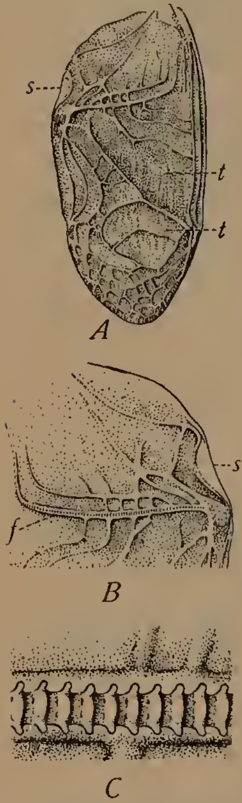

Fig. 89. — Fore wing of *Gryllus;* A, as seen from above, that part of the wing which is bent down on the side of the abdomen is not shown; *s*, scraper; *t*, *t*, tympana. B, base of wing seen from below; *s*, scraper; *f*, file. C, file greatly enlarged.

Figure 89 represents the musical apparatus of a cricket. From this it will be seen that the large veins divide the wing-covers into disk-like membranous spaces. If the principal vein which extends diagonally across the base of the wing-cover be examined with a microscope, it will be seen to be furnished with ridges like those of a file (Fig. 89, *C*). On the inner margin of the wing-cover, a short distance toward the base from the end of the principal vein, there is a hardened portion which may be called the scraper. This is shown enlarged at *s* in the figure. Each wing-cover is therefore provided with a file and a scraper. When the cricket wishes to make his call, he elevates his wing-covers at an angle of about forty-five degrees with the body; then holding them in such a position that the scraper of one rests upon the file of the other, he moves the wing-covers back and forth sidewise so that the file and the scraper rasp upon each other. This throws the wing-covers into vibration, and produces the call.

The crickets do not constitute a large group yet there is considerable diversity of form among them. The more common species may be placed in three rather distinct groups; the tree-crickets, the field-crickets, and the mole-crickets.

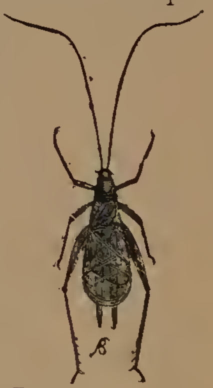

Fig. 90. — *Œcanthus niveus*, male.

THE TREE-CRICKETS

The common name of this group was suggested by the fact that these crickets are very apt to inhabit trees; but they occur also on shrubs, or even on high herbs and tall grass. They are delicate insects, many of which are of a light green color. Most of them belong to the genus *Œcănthus* and the one that often attracts attention is the snowy tree-cricket, *O. nĭveus* (Fig. 90). Although usually unseen the males are evident in late summer and in the autumn by their songs. Their song is begun early in the evening and is continued throughout the night; it consists of a monotonous series of high-pitched trills rhythmically repeated indefinitely. It is a remarkable fact that all of these crickets that are chirping in any locality chirp in unison. Except where the true katydid is heard, this is the most conspicuous insect song heard in the night in the regions where this species occurs.

Another species, *O. nigricŏrnis*, attracts attention because the female lays her eggs in a row in the stems of plants, especially in the canes of raspberries (Fig. 91).

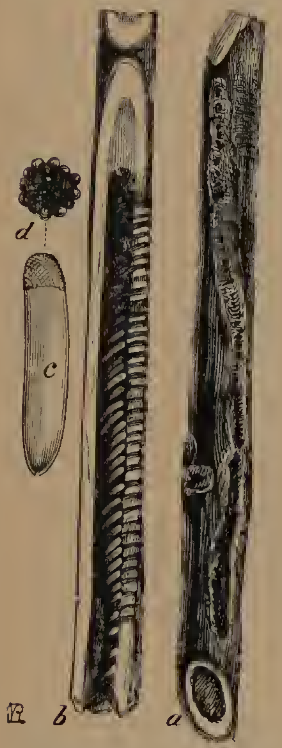

Fig. 91. — Stem of black raspberry with the eggs of *Œcanthus nigricornis*: *c*, *d*, egg enlarged. (From Riley.)

THE FIELD-CRICKETS

These are the common brown to almost black crickets with which we are probably most familiar.

They abound everywhere, in pastures, meadows, and gardens; and certain species enter our dwellings. They lurk under stones or other objects on the ground or burrow into the earth. They are chiefly solitary, nocturnal insects; yet many can be seen in the fields in the daytime. They usually feed upon plants but are sometimes predacious. With most species the eggs are laid in the autumn, usually in the ground, and are hatched in the following summer. The greater number of the old crickets die on the approach of winter; but a few survive the cold season. In many of the species there are both short-winged and long-winged forms. In Figure 92 is shown a common short-winged form. The house cricket of Europe, *Gryllus domĕsticus*, is now present in the northeastern United States.

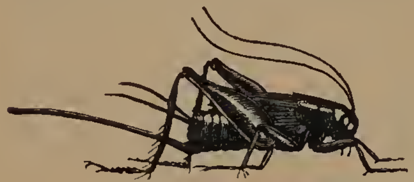

Fig. 92. — *Gryllus*

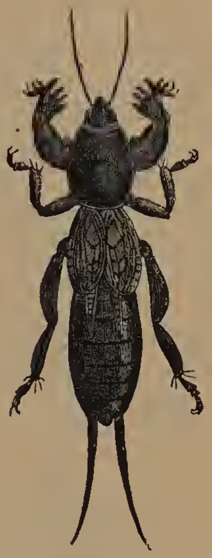

Fig. 93. — *Gryllotalpa hexadactyla.*

THE MOLE-CRICKETS

These are called mole-crickets because they burrow in the ground like moles. The form of the body is suited to this mode of life. The front tibiæ, especially, are fitted for digging; they are greatly broadened, and shaped somewhat like hands, or the feet of a mole (Fig. 93).

The mole-crickets are not common insects in this country; but occasionally they are found in great numbers in a limited locality. They make burrows in moist places from six to eight inches below the surface of the ground, and feed upon the tender roots of various plants, and also on other insects. The eggs are deposited in a neatly constructed subterranean chamber, about the size of a hen's egg.

In this country, at least, mole-crickets are nocturnal in habits, coming forth at night to feed and remaining hidden in their burrows during the day.

Family Locustidæ*

The Locusts or Short-horned Grasshoppers

The family Locustidæ includes the locusts or short-horned grasshoppers. These are common and well-known insects. The antennæ are much shorter than the body, and consist of not more than twenty-five segments. The ovipositor of the female is short and composed of separate plates; and the basal segment of the abdomen is furnished on each side with a tympanum, the external parts of the organs of hearing (Fig. 94).

It is to these insects that the term *locust* is properly applied; for the locusts of which we read in the Bible, and in other books published in the older countries, are members of this family. Unfortunately, in the United States the term *locust* has been applied to the Periodical Cicada, a member of the order Homoptera, described later.

Locusts lay their eggs in oval masses and cover them with a tough substance. Some species lay their eggs in the ground. The female makes a hole in the ground with her ovipositor, which is a good digging-tool. Some species even make holes in fence-rails, logs, and stumps; then, after the eggs are laid, the hole is covered up with a plug of gummy materials. There is but one generation a year, and in most cases the winter is passed in the egg-state. This family is of great economic importance, as the members of it usually appear in great numbers in every region where plants grow, and often do much damage.

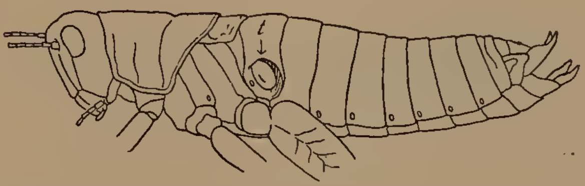

Fig. 94. — Side view of Locust with wings removed to show ear. See the arrow.

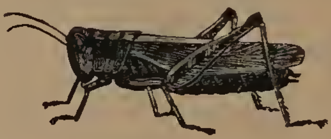

Fig. 95. — *Melanoplus femur-rubrum.*

The males of many locusts are able to produce sounds. This is done in two ways: first, certain species rub the inner surface of the hind femora, upon which there is a row of minutė spines, against the outer surface of the wing-covers. In this case each wing-cover serves as a fiddle, and each hindleg as a fiddle-bow. Second, other species rub together the upper surface of the front edge of the hind-wings and the under surface of the wing-covers. This is done while the locust is flying and the result is a crackling sound.

There are very many species of locusts in the United States. We have space to refer to only a few here.

The most familiar member of the family is the red-legged locust, *Melănoplus femur-rūbrum* (Fig. 95). It is more abundant than any other species throughout the United States, except in the high dry lands of the central part of the continent where the Rocky Mountain locust, *Melănoplus sprētus*, has its breeding grounds.

The Rocky Mountain locust is only about one to one and a quarter inches long and resembles closely the red-legged locust but has somewhat longer wings. In past years when the food of this locust has become scarce in its high dry home, it has migrated to the lower and more fertile regions of Kansas, Iowa and Nebraska where it has devastated the crops over large areas.

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* This family is termed the Acrididæ by some writers, other writers use the family name Acridiidæ.

It will be remembered that at one time it almost produced a famine in Kansas and the neighboring states. Fortunately the young of this insect hatched in the low regions are not healthy, and die before reaching maturity. Consequently the plagues caused by the emigration of this insect are of short duration. There are several other species of Melanoplus common in this country, but they can be distinguished only by very careful study. One, the "big yellow locust", *Melănoplus differentiālis,* is about $1\frac{5}{8}$ inches long, yellowish-brown in color and often so abundant in the middle West that it injures fields of grass and grain very seriously.

The Carolina locust, *Dissosteīra carolīna*, is common throughout the United States and Canada, and at the North is our largest species. It lives in roads and on bare places, and its color matches the soil on which it lives. It is usually pale yellowish or reddish-brown or slate color, with small dusky spots. The hind wings are black, with a broad yellow edge. It measures from one inch and a half to nearly two inches in length.

The clouded locust, *Encoptolŏphus sŏrdidus* (Fig. 96), is very common in the Eastern United States during the autumn. It abounds in meadows and pastures, and attracts attention by the crackling sound made by the males during flight. Its color is dirty brown, mottled with darker spots.

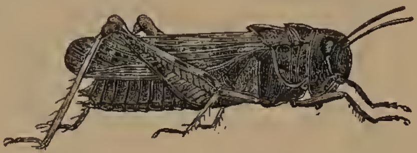

FIG. 96. — *Encoptolophus sordidus.*

The American locust, *Schistŏcerca americāna*, is a fine species nearly 3 inches long. It is found in the southern states and as far north as Connecticut and Iowa (Fig. 97). The pellucid locust, *Camnūla pellūcida*, scarcely an inch in length, has clear pellucid hind wings and occurs in the northern United States south to Arizona. It is often injurious to crops.

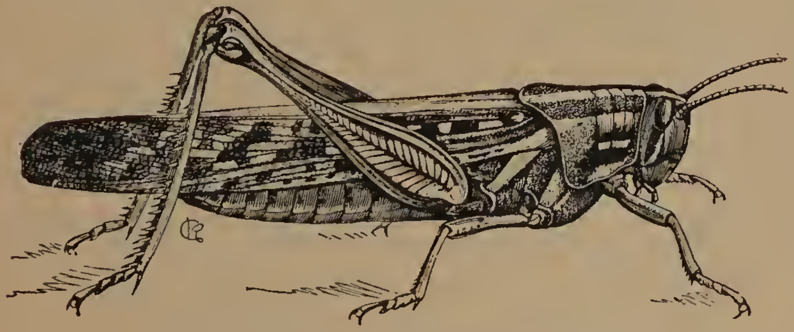

FIG. 97. — *Schistocerca americana.* (From Riley.)

The lubber grasshopper, *Brachȳstola măgna*, is a large, clumsy species in which the wings are vestigial; it is confined to the central portion of North America.

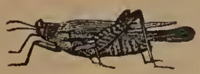

FIG. 98.— *Acrydium.*

The pigmy locusts. — There is a group of small locusts of which *Acrȳdium* (Fig. 98) is an example, which is notable for the shape of the pronotum. This projects backward like a little roof over the wings, and often extends beyond the end of the abdomen. With these insects the wing-covers are reduced to small rough scales, the wings being protected by the large pronotum. These insects are commonly found in low, wet places, and on the borders of streams. Their colors are usually dark, and are often protective, closely resembling that of the soil upon which they occur. These locusts are very active, jumping great distances.

Family Phasmidæ

The Walking-sticks and the Leaf-insects

The Phasmidæ are of especial interest on account of the remarkable mimetic forms of the different species. In those species that are found in the United States, except one in Florida, the body is linear (Fig. 99), wingless, and furnished with long legs and antennæ. This peculiar form has suggested the name *walking-sticks* which is commonly applied to these insects.

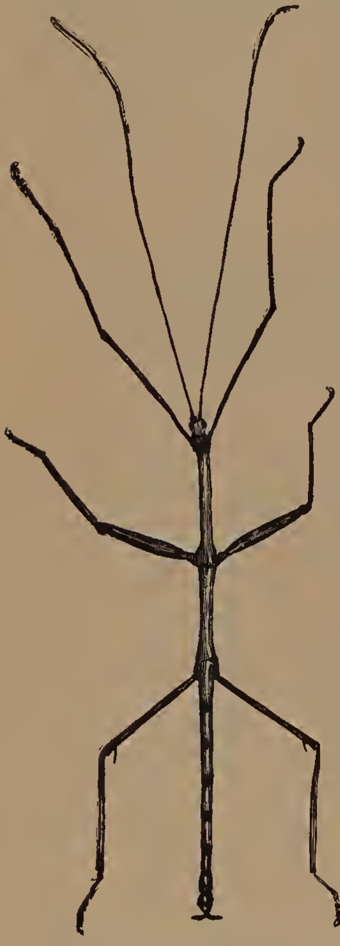

Fig. 99. — A Walking-stick.

These insects are strictly herbivorous; they are slow in their motions, and often remain quiet for a long time in one place. They evidently depend on their mimetic form for protection. In addition to this some species have the power of ejecting a stinking fluid, which is said to be very acrid; this fluid comes from glands placed in the thorax.

The eggs are scattered on the ground beneath the plants upon which the insects feed, the female, unlike most Orthoptera, making no provision for their safety. In our common northern species the eggs are dropped late in the summer and do not hatch till the following spring, or even till the second spring in some cases.

Our common northern walking-stick is *Diapherŏmera femorāta* (Fig. 99). The range of this species extends into Canada. It is a quite common insect, and on several occasions has appeared in such great numbers as to be seriously destructive to the foliage of forest trees; but these outbreaks have been temporary.

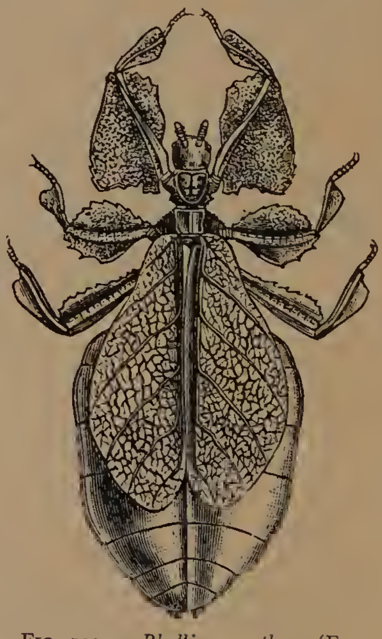

Fig. 100. — *Phyllium scythe.* (From Sharp, after Westwood.)

Among the more striking in appearance of the walking-sticks found in the South are *Megaphăsma dĕntricus*, our largest species, measuring from 5 to 6 inches in length, and *Anisomŏrpha buprestoides*, a yellowish brown species, about half as long as the preceding.

While our species are all wingless, except *Aplopus mayeri*, found in southern Florida, many exotic species are furnished with wings; and with some of these the wings resemble leaves. Among the more remarkable of the leaf-insects, as they are known, are those of the genus *Phyllium* (Fig. 100), the members of which occur in the tropical regions of the Old World.

Family Mantidæ

The Praying Mantes or Soothsayers

Certainly they are pious-looking fellows, with their front legs clasped together in front of their meek, alert faces, and it is no wonder that they are called praying mantes. But the only prayer that could ever enter the mind of a mantis would be that some unwary insect might come near enough for him to grab it with his hypocritical claws, and so get a meal.

The praying mantes are easily recognized by the unusual form of the prothorax and of the first pair of legs (Fig. 102). The prothorax is elongated and the front legs are large and fitted for seizing prey. The coxæ of the front legs are very long, and the femora and tibiæ of these legs are armed with spines; the tibia of each leg can be folded back against the femur so that the spines of the two will securely hold any insect seized by the praying mantis.

With some species the wings resemble leaves of plants in form and coloring.

All of the species are carnivorous, feeding on other insects. They do not pursue their prey but wait patiently with the front legs raised like uplifted hands in prayer, until it comes within reach, when they seize it.

The eggs of the Mantidæ are encased in chambered oöthecæ, which are usually fastened to the stems or twigs of plants (Fig. 101).

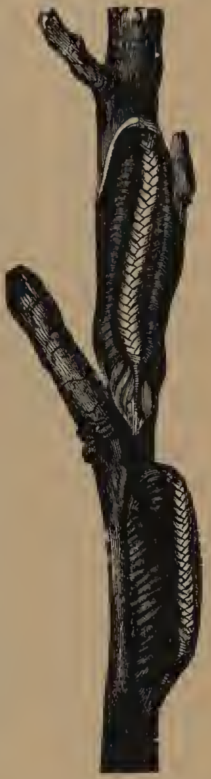

Fig. 101. — Egg-cases of *Stagmomantis carolina*. (From Riley.)

Most of the members of this family are tropical insects; a few species, probably less than twenty, live in the southern half of the United States; and one of our native species, *Stagmomăntis carolina* (Fig. 102), is found as far north as Maryland and southern Indiana.

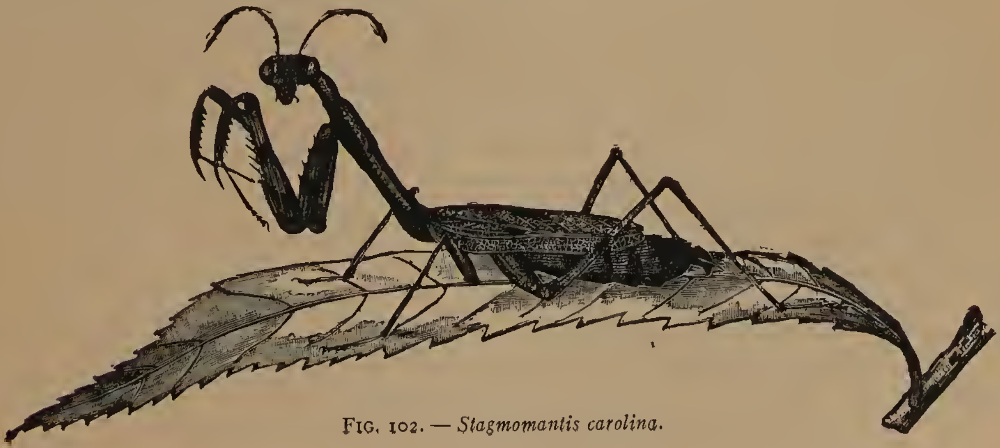

Fig. 102. — *Stagmomantis carolina*.

Recently two exotic species have been introduced into the Northern States, probably by the importation of oöthecæ on nursery stock, and have become established here. These are the *Măntis religiōsa* of Europe, which was first observed in this country near Rochester, N. Y., in 1899, and *Paratenodēra sinĕnsis* of China and Japan, which was first observed here at Philadelphia about 1895.

Family Blattidæ

The Cockroaches

The cockroaches are well-known insects with oval depressed bodies, long slender antennæ and legs fitted for running. The head is bent downward and the mouth-parts project backwards between the first pair of legs.

After every one is in bed at night and all is quiet in the kitchen where there are water-pipes, often a throng of these small creatures come forth from hiding-places and, like brownies, take possession of everything. They race around everywhere, trying to find something to eat, almost anything that comes in reach of their greedy jaws. They eat book-bindings and bedbugs, if they find them, with equal alacrity.

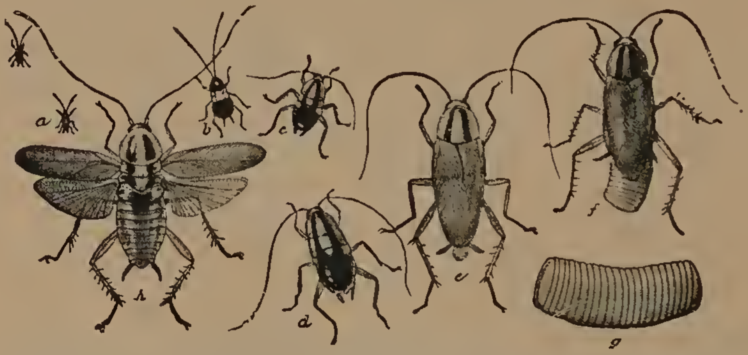

Fig. 103. — The Croton-bug; *a*, first instar; *b*, second instar; *c*, third instar; *d*, fourth instar: *e*, adult; *f*, adult female with egg-case; *g*, egg-case, enlarged; *h*, adult with wings spread. All natural size except *g*. (From Howard and Marlatt.)

Not only are these insects very destructive to our possessions, but owing to their fetid odor merely the sight of them awakens disgust.

The eggs of cockroaches are enclosed in purse-like capsules (Fig. 103, g). These capsules, or oöthecæ, vary in form in different genera, but are more or less bean-shaped. Within, the oötheca is divided into two parallel spaces, in each of which there is a row of separate chambers, each chamber enclosing an egg. The female often carries an oötheca protruding from the end of the abdomen for several days. It has been found that a single female may produce several oöthecæ. Probably the most effective means of ridding premises of cockroaches is by dusting the places they frequent with commercial sodium fluoride.

In the Northern States our native species are usually found in the fields or forests under sticks, stones, or other rubbish. But certain imported species become pests in dwellings. In the warmer parts of the country, however, native and foreign species alike swarm in buildings of all kinds, and are very common out of doors.

The croton-bug, *Blattĕlla germănica*, is the most common house cockroach in the North. It came from Europe and was first found about water-pipes in New York City connected with the Croton aqueduct. It is pale brown and only a little over ½ an inch long (Fig. 103).

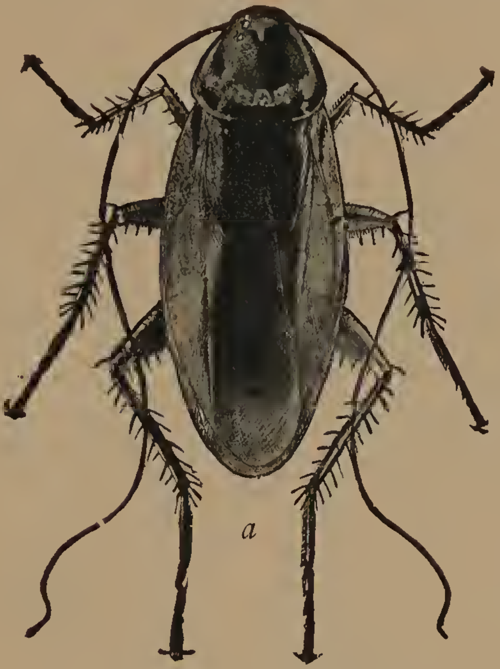

Fig. 104. — The American cockroach.

The American cockroach, *Periplanēta americāna* (Fig. 104), is a native of tropical or subtropical America that has become distributed both in tropical and mild climates over the entire world. This is a large species measuring from 1 to 1⅓ inches in length.

The oriental cockroach, *Blătta orientālis*, is supposed to have come to us from Asia. It measures from ⅔ of an inch to nearly an inch in length and is blackish-brown in color. The wings of the female are very short.

CHAPTER VI

ORDER ZORAPTERA *

So little is known of this order which was established in 1913, that it is impossible at this time to define with any certainty, the characters of the group. But a single genus, *Zorŏtypus*, is known, and at this time, only about half a dozen species have been discovered. These have been found as follows: one each in Africa, Ceylon, Java, and Costa Rica and two in Florida. One of the species from Florida has also been found in Texas. In addition, a colony of one species has been discovered in northern Virginia.

The known species are all minute, the largest measuring only $\frac{1}{10}$ of an inch in length. The Florida species contain both winged and wingless forms, the former being females although there are also wingless females.

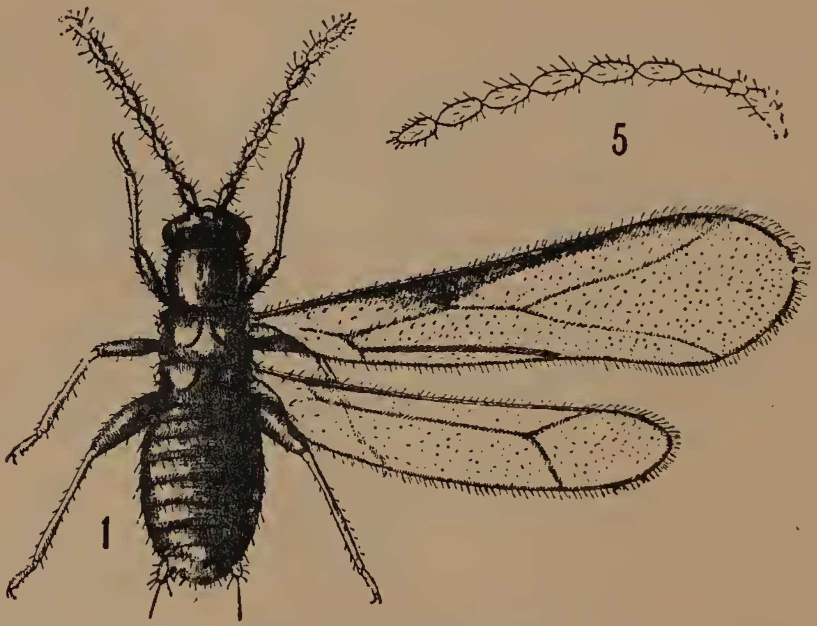

Fig. 105. — *Zorotypus hubbardi;* *1*, winged adult female; *5*, antenna of a wingless individual. (From An Introduction to Entomology.)

The wingless adults resemble small termites. They have strong mandibles but are blind. The legs are fitted for running and the antennæ are nine-segmented. The winged females have compound eyes and two pairs of wings (Fig. 105).

These insects are social and live in colonies of various sizes under the bark of logs and stumps and frequently near the galleries of termites. It was thought, at first, that they might live as inquilines in the nests of termites; but recent observations do not support this view.

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* Zorăptera: *zoros* (ζυρός), pure; *apterous* (ἄπτερος), without wings.

CHAPTER VII

ORDER ISOPTERA *

The Termites or White-ants

The members of this order are social insects, living in colonies like ants. Each species consists of several distinct castes, the number of which differs in different species. Each caste includes both male and female individuals. In most species there are four castes as follows: first, the first reproductive caste, in which the wings become fully developed and are used for a swarming flight and then shed; second, the second reproductive caste, in which the wing-buds remain short; the individuals are sexually mature but retain the nymphal form; third, the worker caste; and fourth, the soldier caste. Except in a single Australian genus, the two pairs of wings are similar in form and in the more general features of their venation; they are long and narrow, and are laid flat on the back when not in use. The abdomen is broadly joined to the thorax; the mouth-parts are formed for chewing; the metamorphosis is incomplete.

The termites or white-ants are chiefly tropical insects; but some species live in the temperate zones. These insects can be easily recognized by the fact that they live in ant-like colonies, by the pale color of the greater number of individuals of which a colony is composed, and by the form of the abdomen, which is broadly joined to the thorax instead of being pedunculate as in ants.

The termites are commonly called white-ants on account of their color and of a resemblance in form and habits to the true ants. In structure the termites and ants are widely separated. In habits there is little more in common than that both are social.

The cuticula of termites is delicate even in adults; the mature winged forms can withstand exposure to dry air for a limited period, as is necessary during their swarming flight; but other members of a colony quickly become shriveled and die if exposed. It is for this reason that they build tubes constructed of earth and excrement for passage-ways, and only rarely appear in the open, and then merely for a brief period.

The mouth-parts resemble those of the grasshoppers; but in the case of the soldier caste the mandibles are very large. The members of the winged sexual caste have compound eyes and a pair of ocelli. The workers and soldiers of most termites are blind but in case of the marching termite of Africa both the workers and soldiers possess eyes.

The wings are long and narrow and when folded on the back of the insect extend far beyond the end of the abdomen. The wings of the sexual forms are shed after their flight. The shedding of the wings is facilitated by the presence in each wing near its base of a curved transverse suture, the *humeral suture*.

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* Isŏptera: *isos* (ἴσος), equal; *pteron* (πτερόν), a wing.

With the termites the number of castes is greater than with the social bees, social wasps, and ants; and each caste includes both male and female individuals. The termites differ also from other social insects in that there are at least two and sometimes three castes whose function is reproduction. The following castes have been found among these insects.

The first reproductive caste. — At a certain season of the year, late spring or early summer for our most common species in the eastern United States, there can be found in the nests individuals with fully developed wings. These are sexually perfect males and females and constitute what is known as the *first reproductive caste.* In these the cuticula is black or dark chestnut in color and the eyes are functional. A little later, these winged individuals leave the nest in a body; sometimes clouds of them appear. After flying a greater or less distance they alight on the ground, and then shed their wings.

At this time the males seek the females and they become associated in pairs. Each of the more fortunate couples that have escaped their enemies, find a suitable place for the beginning of a nest and become the founders of a new colony. Such a pair are commonly known as the *king* and the *queen* of the colony; they are also known as the *primary royal pair.*

After the nest has been begun, the abdomen of the female becomes greatly enlarged, as a result of the growth of the reproductive organs and their products; this is greater in certain exotic species than it is in those found in this country. Figure 106 represents in natural size the queen of a species found in India. This queen is comparatively small. In some species the queens become 6 to 8 inches in length; such queens are incapable of locomotion and rest in a cell with nothing to do but lay eggs. In our native species of termites the queens do not become so large and they do not lose their power of movement.

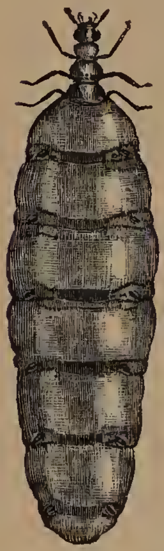
Fig. 106. — Queen white-ant, *Termes gilvus.*

The second reproductive caste. — There are frequently found in the nests of termites individuals which are sexually mature but which retain the nymphal form of the body, having short wing-buds which do not develop further. These individuals constitute *the second reproductive caste,* which is represented by both males and females. The members of this caste are pale in color; their compound eyes are only slightly pigmented; and they never leave the nest unless by subterranean tunnels. If a primary king or queen dies, its place is taken by individuals of the second reproductive caste. For this reason, the members of this caste are commonly known as *substitute kings* and *queens* or as *complemental kings* and *queens.*

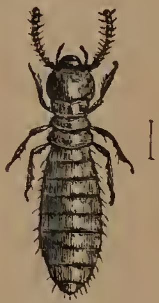
Fig. 107.— Worker of *Reticulitermes flavipes.*

The workers. — If a termite nest be opened at any season of the year there will be found a large number of wingless individuals of a dirty white color, usually blind, and of the form represented by Figure 107. These are named the *workers,* for upon them devolve nearly all of the labors of the colony. A study of the internal anatomy of workers has shown that both sexes are represented in this caste. The worker caste is not always present.

The soldiers. — Associated with the workers, and resembling them in color and in being wingless, there occur numerous representatives of another caste, which can be recognized by the enormous size of their heads and mandibles (Fig. 108); these are the soldiers. They are so named because it is believed that their chief function is the protection of the colony; but they do not seem to be very effective in this. Among the soldiers, as among the workers, both sexes are represented.

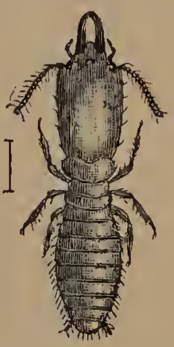

Fig. 108. — Soldier of *Reticulitermes flavipes.*

The nest-building habits of these insects are remarkable. In the tropics certain species build mound nests ten or twelve feet or more in height. Other species build large globular masses upon the trunks or branches of trees or upon other objects. Owing to the delicacy of their cuticula and the consequent danger of becoming shriveled if exposed, the termites build covered ways from their nests to such places as they wish to visit, if they are in exposed situations. These exposed nests are composed chiefly of the excreted undigested wood upon which the insects have fed. This is molded into the desired form and on drying it becomes solid.

The termites that live in the United States do not build exposed nests; and, as the queens do not lose the power of movement, there is no permanent royal cell, centrally located. Some of our species mine in the earth, their nests being made under stones or other objects lying on the ground; some burrow only in wood; and others that burrow in the ground extend their nests into wood.

In the warmer parts of this country and in the tropics termites are a great pest for they destroy buildings by mining into the foundation beams and into the timbers of the framework. Certain methods have been devised for the construction of buildings in warm countries for the purpose of making them termite-proof.

Termites also destroy furniture and books, especially when the latter are stored in basements. In infesting anything composed of wood, they eat out the interior, leaving a thin film on the outside. Thus a table may appear to be sound, but crumble to pieces beneath a slight weight, entrance having been made through the floor of the house and the legs of the table.

While termites infest chiefly dead wood, there are many records of their infesting living plants, especially young orange and pecan trees in the South.

The common species of termite in the northeastern United States is *Reticulitermes flavipes.* It often infests the wooden benches in greenhouses and in some localities undermines buildings by eating out the inside of the foundation timbers and then burrowing into the framework.

CHAPTER VIII

ORDER NEUROPTERA *

The Horned Corydalus, the Lacewing-flies, the Ant-lions and others

The members of this order have four wings; these are membranous and are usually furnished with many veins and cross-veins. In most members of the order, the wings have been specialized by the addition in the preanal area of many supernumerary veins of the accessory type. The mouth-parts are formed for chewing. The tarsi are five-jointed. The cerci are absent. The metamorphosis is complete.

The order Neuroptera as now restricted differs greatly in extent from the Neuroptera of the early entomologists. Formerly there were included in this order many insects that are no longer believed to be closely related.

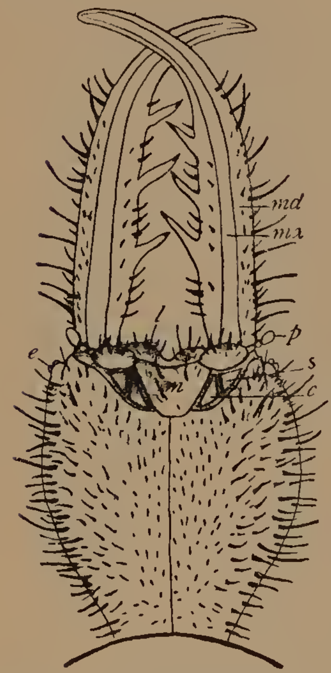

FIG. 109. — Ventral side of mouth-parts of an ant-lion: *md*, mandible; *mx*, maxilla. Much enlarged.

The wings of the Neuroptera are membranous and are usually furnished with many wing-veins. The two pairs of wings are similar in texture and usually in outline; in some the fore wings are slightly larger than the hind wings, in others the two pairs of wings are of the same size. The anal area is small in both fore and hind wings; it is rarely folded (Sialidæ), and then only slightly so.

The mouth-parts are formed for chewing. In several families the larvæ suck the blood of their prey by means of their peculiarly modified mandibles and maxillæ. The mouth-parts of the larva of an ant-lion will serve to illustrate this type of mouth-parts (Fig. 109).

In this insect the mandibles (*md*) are very long, curved at the distal end, fitted for grasping and piercing the body of the prey, and armed with strong spines and setæ. On the ventral aspect of each mandible there is a furrow extending the entire length of the mandible; and over this furrow the long and slender maxilla (*mx*) fits. On the dorsal aspect of the maxilla there is also a furrow. These two furrows form a tube which extends from the tip of the combined mandible and maxilla to the base of this organ where it communicates with the mouth cavity. Through this tube the blood of the prey is conveyed to the mouth.

The metamorphosis is complete. The larvæ that are known are predacious or parasitic; a few of them are aquatic, Sialidæ, Sisyridæ, and certain exotic forms, but more of them are terrestrial; some when full-grown enter the ground and make earthen cells in which they transform, but most of them spin cocoons. The silk of which these cocoons are made, in the case of those in which the silk-organs have been described, is secreted by modified Malpighian vessels and is spun from the anus.

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* Neurŏptera: *neuron* (νεῦρον), a nerve; pteron (πτερόν), a wing.

The known Neuroptera of the world represent twenty families. Thirteen of these families are represented in North America; these can be separated by the following table.

TABLE OF THE FAMILIES OF NORTH AMERICAN NEUROPTERA

A. Prothorax as long as or longer than the mesothorax and metathorax combined.
  B. Fore legs greatly enlarged and fitted for grasping. p. 71 ......Mantispidæ
  BB. Fore legs not enlarged and not fitted for grasping. p. 71 ......Raphidiidæ
AA. Prothorax not as long as the mesothorax and metathorax combined.
  B. Hind wings broad at base and with the anal area folded like a fan when not in use. p. 68 ....Sialidæ
  BB. Hind wings narrow at base and not folded like a fan when closed.
    C. Wings with very few veins and covered with whitish powder. p. 73..Coniopoterygidæ
    CC. Wings with numerous veins and not covered with powder.
      D. Antennæ gradually enlarged towards the end or filiform with a terminal knob.
        E. Antennæ short; wings with an elongate cell behind the point of fusion of veins Sc and R_1. p. 70 ....Myrmeleonidæ
        EE. Antennæ long; wings without an elongate cell behind the point of fusion of veins Sc and R_1. p. 73...........................Ascalaphidæ
      DD. Antennæ not enlarged towards the end.
        E. Male with pectinate antennæ; female with an exserted ovipositor. p. 72 ....Dilaridæ
        EE. Antennæ not pectinate in either sex; female without exserted ovipositor.
          F. Radius of the fore wings with apparently two or more sectors.
            G. Radius of the fore wings with apparently two sectors, one of which is vein R_{2+3} and the other vein R_{4+5}. p. 72 ....Sympherobiidæ
            GG. Radius of the fore wings with three or more sectors. Veins R_4 and R_5 arise separately from vein R_1; one or more definitive accessory branches of the radius of the fore wings present. p. 72...Hemerobiidæ
          FF. Radius of the fore wings with a single sector.
            G. Radial sector of the fore wings without definitive accessory veins although marginal accessory veins are present. p. 72 ....Sisyridæ
            GG. Radial sector of fore wings with definitive accessory veins.
              H. Transverse veins between the costa and subcosta simple. p. 69 ....Chrysopidæ
              HH. Many of the transverse veins between the costa and subcosta forked.
                I. Humeral cross-vein recurved and branched; first radio-medial cross-vein of the hind wings longitudinal and sigmoid. p. 73..Polystœchotidæ
                II. Humeral cross-vein not recurved; first radio-medial cross-vein of the hind wings transverse. p. 73..................Berothidæ

Of the foregoing families but three are of common enough interest to justify any extended discussion in this brief work. These are the Sialidae which embraces the horned Corydalus and the fish-flies, the Myrmelionidae which includes the curious ant-lions, and the Chrysopidae or lacewing-flies. The lesser known families are grouped at the end of the chapter. A more extended discussion of them may be found in "An Introduction to Entomology" by J. H. Comstock.

Family SIALIDÆ

The Sialids

The members of the Siălidæ differ greatly in size and appearance; but they agree in having the hind wings broad at the base with the anal area folded like a fan when not in use. In this respect they differ from all other Neuroptera.

The larvæ are aquatic, predatory, and possess paired, lateral filaments on most or on all of the abdominal segments. They leave the water when full-grown and transform in earthen cells on the banks of the streams or lakes in which they lived as larvæ. The eggs are deposited in clusters on any convenient support near the water, in such situations that the young larvæ can easily find access to the water. The adults fly but little; they are most often found resting on some support near the water, with the wings folded over the abdomen.

The smoky alder-fly, *Sīalis infumāta,* is a dusky-brownish small insect with a wing-expanse of about one inch. Its eggs are laid in patches on objects near or over the water. The larva lives beneath stones in swiftly flowing streams. It has paired lateral filaments on the first seven abdominal segments and the last abdominal segment is prolonged into a tapering lash-like filament (Fig. 110).

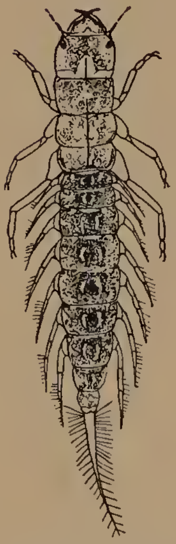
FIG. 110.—Larva of the smoky alder-fly.

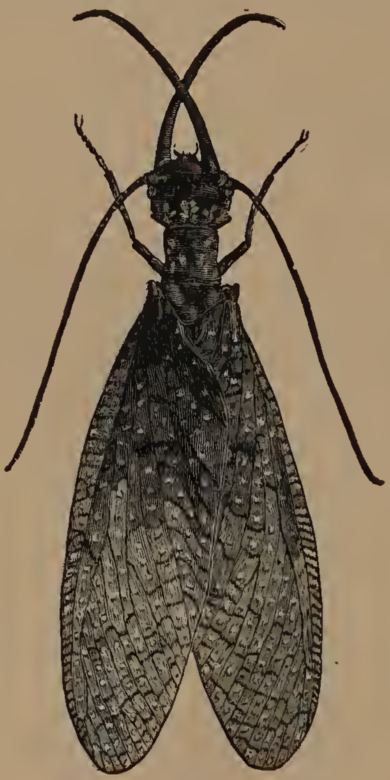
FIG. 111. — *Corydalus cornutus.*

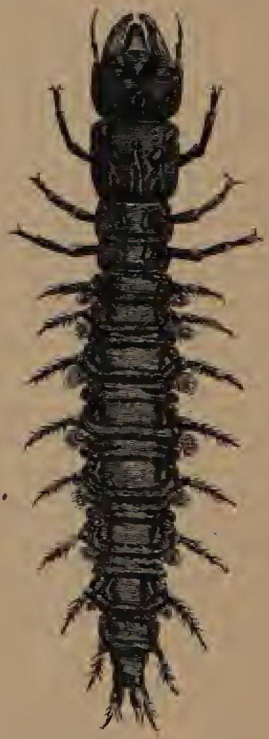
FIG. 112. — *Corydalus cornutus,* larva.

The species that is most likely to attract attention is the horned corydalus, *Cory̆dalus cornūtus.* This is a magnificent insect, which has a wing-expanse of from four to nearly five and a half inches. Figure 111 represents the male, which has remarkably long mandibles. The female resembles the male, except that the mandibles are comparatively short. The larvæ are called *dobsons* or *hellgrammites* by anglers and are used by them for bait, especially for bass. Figure 112 represents a full-grown dobson, natural size. These larvæ live under stones in the beds of streams. They are most abundant where the water flows swiftest. They are carnivorous, feeding upon the nymphs of stoneflies, mayflies, and other insects. When about two years and eleven months old, the larva leaves the water, and makes a cell under a stone or some other object on or near the bank of the stream. This occurs during the early part of the summer; here the larva changes to a pupa. In about a month after the larva leaves the water the adult insect appears. The eggs are then soon laid; these are attached to stones or other objects overhanging the water. They are laid in blotch-like masses, which are chalky-white in color, and measure from half an inch to nearly an inch in diameter. A single mass contains from two thousand to three thousand eggs. When the larvæ hatch they at once find their way into the water, where they remain until full-grown.

There are other common species of the family which closely resemble *Corydalus* but are smaller, the larger ones measuring less than two and a half inches in length, and having a wing-expanse of not more than four inches.

The comb-horned fish-fly *Chaulīodes pectinicŏrnis*, has serrate antennæ and grayish wings while a closely related fish-fly, *Nigrōnia serricŏrnis*, also with serrate antennæ, has darker, more brownish wings, spotted with white dots.

Family Chrysopidæ

The Lacewing-flies or Aphis-lions

The family Chrysopidæ includes the insects commonly known as lacewing-flies; these and their larvæ, the aphis-lions, are common and well-known insects; they are found upon herbage and the foliage of shrubs and trees throughout the summer months (Fig. 113).

The adults are easily recognized by their delicate lace-like wings (Fig. 114) and their green or yellowish-green color. Their eyes are large and shine like molten gold when alive. They are often called *golden-eyed flies;* and because some of them when handled emit a disagreeable odor they have been called *stink-flies*, an undesirable name for such beautiful insects.

The larvæ of the lacewing-flies are known as aphis-lions, because they feed upon aphids; they are found on the foliage of

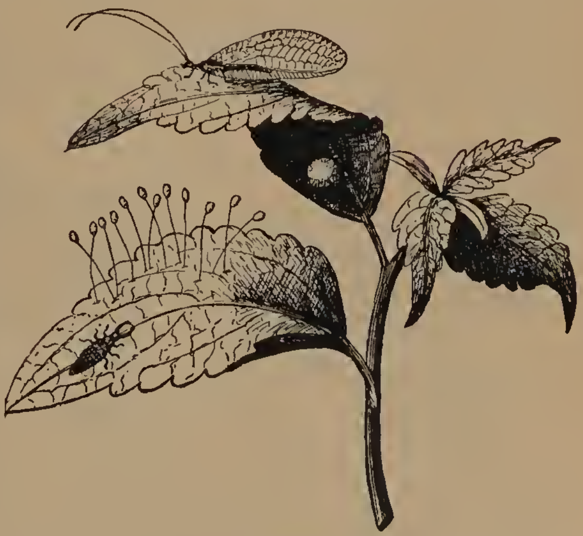

Fig. 113. — Eggs, larva, cocoon, and adult of *Chrysopa*.

plants infested by these pests; they also feed upon other small insects and the eggs of insects; they are spindle-shaped (Fig. 113) and are furnished with piercing and sucking mouth-parts like those of ant-lions.

Nearly all aphis-lions are naked; but a few species cover themselves with the skins of their victims and other debris.

The cocoons are generally found on the lower sides of leaves or on the supports of plants; they are spherical and white and composed of dense layers of silk. In order to emerge the insect cuts a circular lid from one side of the cocoon; this is done by the pupa by means of its mandibles. After emerging from its cocoon, the pupa crawls about for a short time before changing to the adult state.

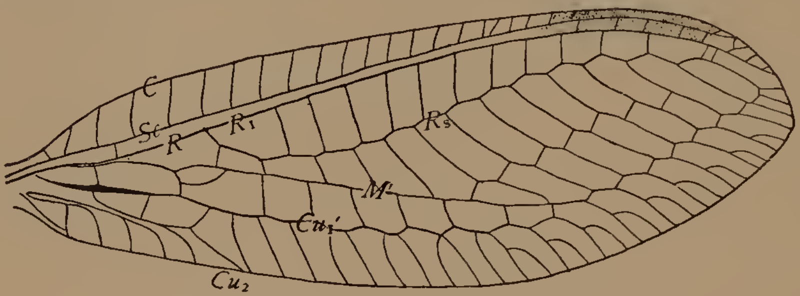

FIG. 114. — Fore wing of a lace-wing fly, *Chrysopa*.

The adults are often attracted to lights at night. A remarkable fact in the life-history of these insects is the way in which the female cares for her eggs. When about to lay an egg she emits from the end of her body a minute drop of a tenacious substance; this she applies to the object on which she is standing and then draws it out into a slender thread by lifting the abdomen; then an egg is placed on the summit of this thread, which dries at once and firmly holds the egg in mid-air.

The eggs are often laid in groups which appear like a tiny forest of white stems with a shining ball at the summit of each.

Family MYRMELEONIDÆ

The Ant-lions

The members of the family Myrmeleonidæ are commonly known as ant-lions. This name was suggested by the fact that the larvæ of the best-known species, those that dig pitfalls, feed chiefly on ants.

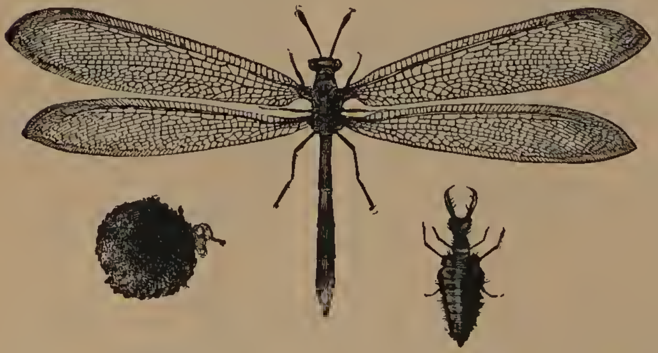

FIG. 115. — Larva, cocoon with pupa-skin projecting, and adult of an Ant-lion.

The adults are graceful creatures. The body is long and slender (Fig. 115); the antennæ are short and enlarged towards the end; the wings are long and narrow and delicate in structure.

The larvæ have broad and somewhat depressed bodies which taper towards each end (Fig. 115). The mouth-parts are large and powerful and are of the piercing and sucking type; they are described on page 64. The pupa state is passed in a spherical cocoon, made of sand fastened together with silk, and neatly lined with the same material (Fig. 115).

The life-histories of comparatively few of the species are known; but certain species, the larvæ of which dig pitfalls in sandy places, have attracted much attention since the earliest days of entomology.

Ant-lions are much more common in the southern and southwestern States than they are in the North. The pitfalls of the larvæ are usually found in sandy places that are protected from rain, as beneath buildings or overhanging rocks. In making these pitfalls the sand is thrown out by an upward jerk of the head, this part of the body serving as a shovel. The pits differ greatly in depth, according to the nature of the soil in which they are made. Their sides are as steep as the sand will lie. When an ant or other wingless insect steps upon the brink of one of these pits, the sand crumbles beneath its feet, and it is precipitated into the jaws of the ant-lion, which is buried in the sand, with its jaws at the bottom of the pit (Fig. 116). In case the ant does not fall to the bottom of the pit, the ant-lion undermines it by throwing out some sand beneath it. These larvæ can be easily kept in a dish of sand, and their habits watched.

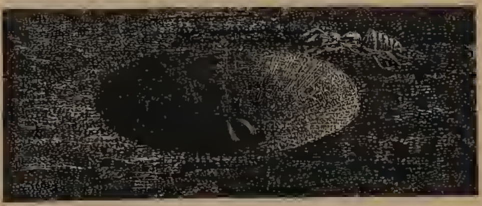

FIG. 116. — Pitfall of an Ant-lion.

The most common ant-lion in the North is *Myrmēleon immaculātus;* the larva of this species makes a pitfall.

For a fuller account of the following families of the Neuroptera the student is referred to "An Introduction to Entomology" by John Henry Comstock.

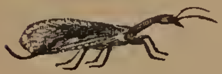

FIG. 117. — *Raphidia,* female.

Family RAPHIDIIDÆ

The Snake-flies

The members of the Raphidiidæ are found in this country only in the far West. They are strange-appearing insects, the prothorax being greatly elongated, like the neck of a camel (Fig. 117).

Family MANTISPIDÆ

The Mantis-like Neuropterons

The members of the Mantispidæ are even more strange in appearance than are those of the preceding family. Here, as in that family, the prothorax is greatly elongated; but the members of this family can be easily recognized by their remarkable fore legs, which are greatly enlarged and resemble those of the praying mantes in form (Fig. 118). These legs are fitted for seizing prey.

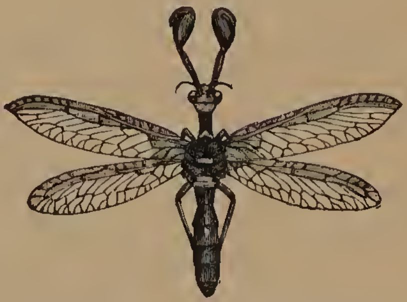

FIG. 118. — *Mantispa.* In the specimen figured the fore legs were twisted somewhat in order to show the form of the parts.

Family Sisyridæ

The Spongilla-flies

The Sisy̌ridæ include a very limited number of small, smoky brown insects. They are called *spongilla-flies* because the larvæ live as parasites in fresh-water sponges, the typical genus of which is *Spongilla*.

Family Sympherobiidæ

The Sympherobiids

This family includes certain insects which were formerly classed with the Hemerobiidæ but which exhibit a type of specialization of the wings that is quite different from that which is distinctively characteristic of that family.

Family Hemerobiidæ

The Hemerobiids

The Hemerobiidæ include insects of moderate size; in most of our species the wing-expanse is between $\frac{1}{2}$ and $\frac{5}{8}$ of an inch; in one species of *Megalōmus* it is only $\frac{1}{4}$ inch. In most of the species the body is brown or blackish and is often marked with yellow; in some the body is pale yellow. The wings are usually hyaline or pale yellowish (Fig. 119).

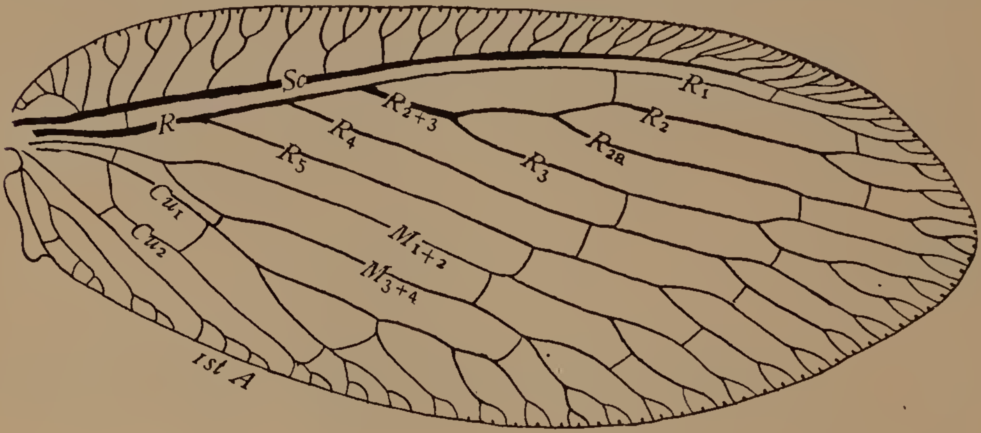

Fig. 119. — Fore wing of *Hemerobius*.

Family Dilaridæ

The Dilaridæ is a small family, representatives of which are found chiefly in the Old World. In this family the antennæ of the male are pectinate; and the female is furnished with an exserted ovipositor.

A single rare species, *Dīlar americānus*, has been found in North America; and of this only a single female individual is known of which the body is scarcely $\frac{1}{8}$ of an inch in length.

Family POLYSTŒCHOTIDÆ

The family Polystœchotidæ was established to receive the genus *Polystœchotes*, of which only two species, both American, are known. These are larger insects than are the members of the allied families, measuring in wing-expanse from 1⅗ inches to 3 inches. They are nocturnal in habits (Fig. 120).

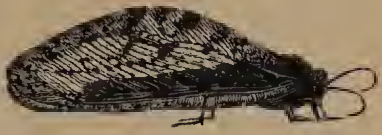

FIG. 120. — *Polystœchotes punctatus.*

Family BEROTHIDÆ

The Berothidæ is a small family, which is represented in North America by a single genus, *Lomamyia*, of which only two species are known.

Family ASCALAPHIDÆ

The Ascalaphids

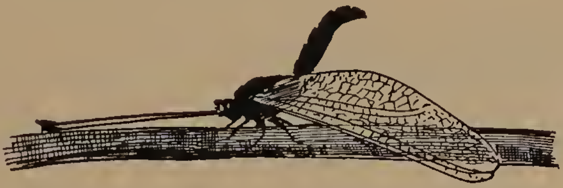

FIG. 121. — An Ascalaphid.

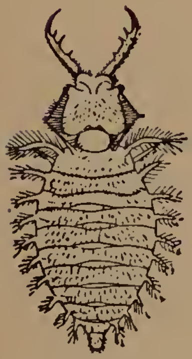

Fig. 121a. — Larva of an Ascalaphid.

The family Ascalaphidæ is quite closely allied to the Myrmeleonidæ; but the members of this family can usually be distinguished from myrmeleonids by the greater length of the antennæ. The larvæ resemble ant-lions in form of the body and possess the same type of mouth-parts (Fig. 121).

Family CONIOPTERYGIDÆ

The Mealy-winged Neuropterons

The Coniopterygidæ is a family of limited extent; and it includes only small insects, the smallest of the Neuroptera; the described American species measure only 3 mm. or less in length. They have the body and wings covered by a whitish powder.

CHAPTER IX

ORDER EPHEMERIDA *

The Mayflies

The members of this order have delicate membranous wings, triangular in outline and with many cross-veins and usually extra longitudinal veins; the hind wings are smaller than the fore wings and are sometimes wanting. The mouth-parts of the adults are vestigial; those of the nymphs are fitted for chewing. The metamorphosis is incomplete.

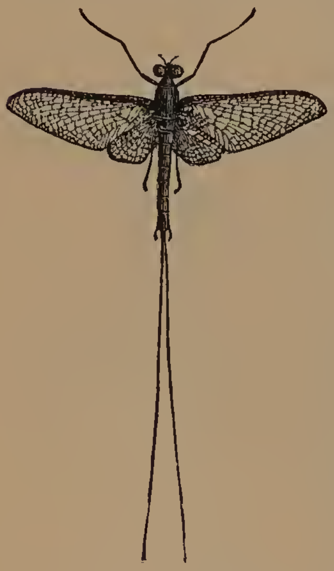

Fig. 122. — Mayfly.

The name of this order is from the Greek word *ephemeros*, lasting but a day. It was given to these insects on account of the shortness of their lives after reaching the adult state. The mayflies are easily distinguished from other net-winged insects by the peculiar shape of the wings and the relative sizes of the two pairs (Fig. 122).

The mouth-parts are nearly wanting, as these insects eat nothing in the adult state; the antennæ are very small; the abdomen is long, soft, and terminated by two or three many-jointed, thread-like appendages.

Mayflies exhibit a remarkable peculiarity in their development. After the insect leaves the water and has apparently assumed the adult form, that is, after the wings have become fully expanded, it molts again. These are the only insects that molt after they have attained functional wings. The terms *subimago* is applied to the instar between the nymph and the final form to the insect, the imago. With some species the duration of the subimago stage is only a few minutes; the insect molts on leaving the water; flies a short distance; and molts again. In others this stage lasts twenty-four hours or more

What is spoken of as the brief or ephemeral life of the mayflies is true only of their existence in the adult state. Strictly speaking, the mayflies are long-lived insects. A few species pass through their life-cycle in a few weeks in midsummer; but as a rule one, two or three years are required for the development of a generation. The greater part of this time is passed, however, beneath the surface of the water as a nymph and after the insect emerges and assumes the adult form its existence is very brief. With many species the individuals leave the water, molt twice, mate, lay their eggs and die in the course of an evening or early morning. In the case of other species the adults may live several days; yet the lives of these are short compared with those of other insects.

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* Ephemĕrida, Ephemera: *ephemeron* (ἐφήμερον), a Mayfly.

The eggs of mayflies are laid on or in the water. Either the female alights at intervals on the water to wash off the eggs or she creeps down into the water to lay her eggs upon the undersides of stones. In either case the eggs finally rest in the water and hatch there into the nymphs which always live in the water. The nymphs breathe by means of tracheal gills which are usually situated along each side of the abdomen. They are usually active and live on bits of plant food found in the water. Some burrow in the bottom silt, others climb actively over green vegetation in the water, while others live in swiftly flowing water where they cling closely to submerged logs and stones.

With many species of mayflies there is great uniformity in the date of maturing of the individuals. Thus immense swarms of them will leave the water at about the same time, and in the course of a few days pass away, this being the only appearance of the species until another generation has been developed. The great swarms of "lakeflies," *Ephĕmera simulăns*, which appear along our northern lakes about the third week of July, afford good illustration of this peculiarity.

Family Ephemeridæ

The Mayflies

The order Ephemerida includes a single family, the Ephemeridæ; the characteristics of this family, therefore, are those of the order, which are given above.

The appearance and habits of the mayflies are certainly well known by those who live in the vicinity of streams, ponds, or lakes.

In river or lake towns, during the warm evenings of late spring or early summer, the electric lights or street lamps are often darkened by myriads of insects that dash against them, and the pavements are made slippery by their dead bodies which have been trampled under foot. They are not the ordinary night-flying moths: if an individual of the thousands that cling to the posts and buildings in the vicinity of the light be examined, it will prove to be a delicate creature with dainty, trembling wings and two or three long, thread-like organs on the end of its body; the body itself is so transparent that the blood within can be seen pulsating. The front wings are large and finely netted, and the hind wings are small or absent (Fig. 123). So fragile are these pale beings that they seem like phantoms rather than real insects. No wonder that poets have sung of them as the creatures that live only a day. It is true that their winged existence lasts often only a day or even a few hours; but they have another life, of which the poet knows nothing. Down on the bottom of a stream, feeding on mud, water-plants, or small insects, lives a little nymph with delicate, fringed gills along its sides and two or three long, many-jointed, and often feathery appendages on the end of the body (Fig. 124). It has strong legs and can both walk and swim. After about the ninth molt — there may be twenty molts in all — there appear on its thorax four little sacs which are the beginnings of wings; with each

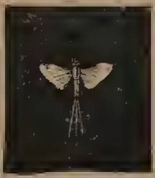

Fig 123. — *Cœnis*, a two-winged Mayfly.

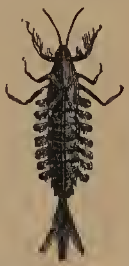

Fig. 124. — Nymph of Mayfly.

molt these grow larger, until finally the last skin of the water-nymph is shed, and gills and mouth-parts are all left behind, and the insect comes forth, a winged mayfly. But there is still another change to be undergone. The insect has not yet reached the adult state. After flying a short distance it alights and sheds its skin again, a thin layer coming off from all parts of its body, even from its wings. After this the delicate creature is more fragile than before. It now has but one duty to perform in its brief life in the air, and that is to lay its eggs. These are sometimes laid on the surface of the water, and sometimes the mother wraps her wings about her like a diving-bell and goes down into the water and deposits her eggs on stones and then dies.

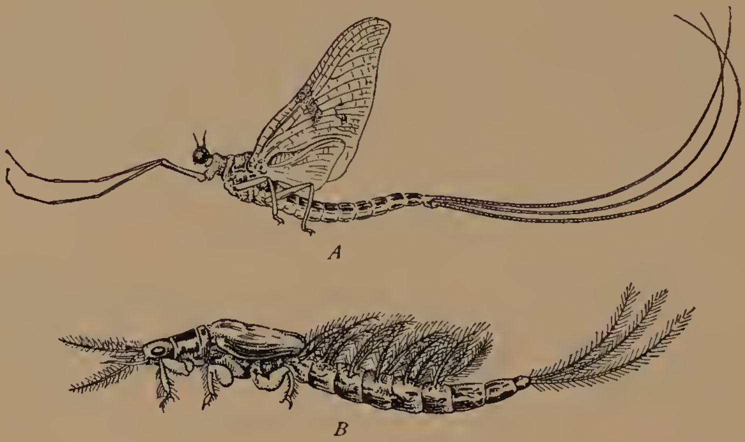

Fig. 124a.

This excellent illustration after Needham, shows a characteristic mayfly (*A*), with its long front legs, triangular wings, and slender caudal setæ. It has transformed from the nymph (*B*), which spent its long life in the water where it obtained air by means of the feathery gills along the sides of the abdomen.

CHAPTER X

ORDER ODONATA *

The Dragonflies and the Damselflies

The members of this order have four membranous wings, which are finely netted with veins; the hind wings are as large as or larger than the fore wings; and each wing has near the middle of the costal margin a joint-like structure, the nodus. There are no wingless species. The mouth-parts are formed for chewing. The metamorphosis is incomplete.

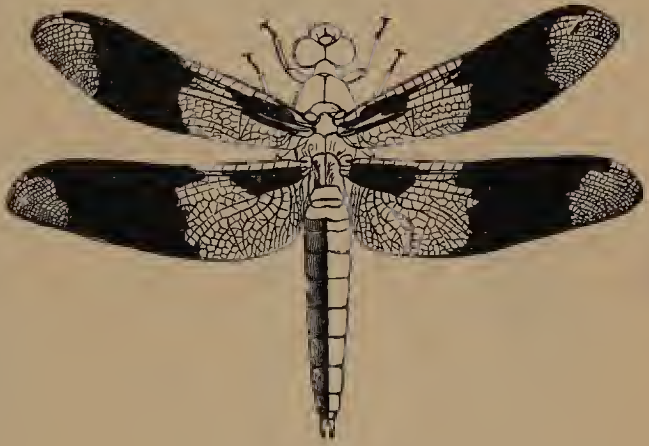
Fig. 125. — A dragonfly.

Dragonflies and damselflies are very common insects in the vicinity of streams, ponds, and lakes; they are well known to all who frequent such places. The dragonflies, especially, attract attention on account of their large size (Fig. 125) and rapid flight, back and forth, over the water and the shores; the damselflies (Fig. 128) are less likely to be noticed, on account of their less vigorous flight.

Suborder ANISOPTERA †

The Dragonflies

The dragonflies constitute a natural division of the Odonata, the suborder, Anisoptera. The wings of dragonflies are usually extended horizontally when they are at rest and the hind wings are as large and often are larger than the front ones. The compound eyes are very large, often occupying most of the surface of the head. In many cases the upper facets of each eye are larger than the lower ones. It is probable that in such eyes the part of the eye with the large facets is for night vision while the part of the eye with the small facets is for day seeing. Most dragonflies appear to have very keen sight for they follow and catch mosquitoes, midges and other small flies while on the wing, much as a hawk swoops downward and captures a weaker bird. But dragonflies are entirely innocent of any harm to mankind. They neither sew up people's

* Odonāta: *odous* (ὀδούς), a tooth.

† Anisŏptera: *anisos* (ἄνισος), unequal; *pteron* (πτερόν), a wing.

ears, as northern children think; nor bring dead snakes to life, as colored people in the South believe; but they are very fierce enemies to their insect kindred. Their long, narrow, closely-netted wings are strong, carrying them swiftly; and their jaws are powerful, and their appetites good; so it is an unfortunate insect that falls in their way.

The nymphs of dragonflies are stout-bodied creatures usually resting among the weeds in the water or in the silt at the bottom of a pond or stream. The abdomen is wide and there are no external gills. They are aquatic, for the female dragonflies lay their eggs either in the stems of water-plants, in submerged logs, or in wet mud or they simply fly down to the water and wash off their eggs from the abdomen or, alighting on a plant-stem, they push the long abdomen down into the water and lay a mass of eggs on a submerged stem or leaf. In any case when the eggs hatch the nymphs find themselves in the water and at once swim off and hunt for some smaller creatures to eat, for they are all carnivorous and ferocious.

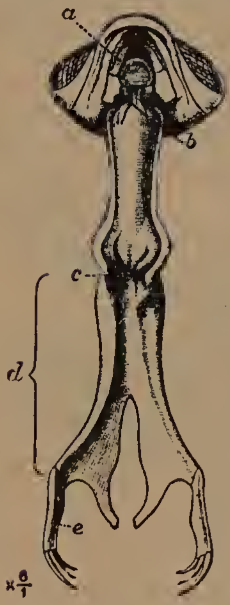

Fig. 126. — Under side of head of a nymph of a damselfly with labium unfolded. (After Sharp.)

They have strong legs and big jaws, and are real insect ogres. The lower lip when extended reaches far out, and is armed with powerful hooks with which to grab their prey (Fig. 126); but when folded up it is so large that it is called a mask and gives the insect's face a comical resemblance to that of a bull-dog. These nymphs have a peculiar method of breathing. The caudal end of the alimentary canal is enlarged into a chamber and lined with tracheæ. The nymph alternately draws water into this cavity and expels it; and thus the air in these tracheæ is purified, this part of the alimentary canal acting as a tracheal gill. This process also helps the insect in swimming, for the water may be expelled with such force that the whole body is sent forward.

When the nymph of a dragonfly is fully grown it leaves the water to transform. The skin of the nymph splits open on the back of the thorax and head, and the adult emerges, leaving the empty skin of the nymph clinging to the object upon which the transformation took place (Fig. 127).

There are two families of dragonflies, the *Æschnidæ*, and the *Libellulidæ*.

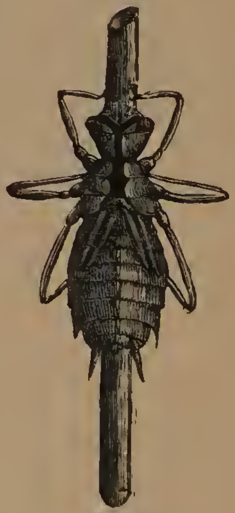

Fig. 127. — Exuviæ of nymph of dragonfly.

Family ÆSCHNIDÆ

The æschnids are mostly large species; among them are the largest, fleetest, and most voracious of our dragonflies. Some of them roam far from water and are commonly seen coursing over lawns in the evening twilight; but most of them fly over clear water. Some of the adults are marked with bright blues and greens. The nymphs eat nearly any animal they can capture and hold.

Family LIBELLULIDÆ

This is a large family including many of our commonest and best-known species of dragonflies; many of them are familiar figures flying over ponds and ditches and by roadsides. Most of them are of well-sustained flight, and are seen continually hovering over the surface of still water; this suggested the common name *skimmers* which has been applied to them.

SUBORDER ZYGOPTERA *

The Damselflies

The damselflies differ so much from the dragonflies and are so much like each other that they also constitute a well-defined suborder, *Zygoptera*, of the Odonata.

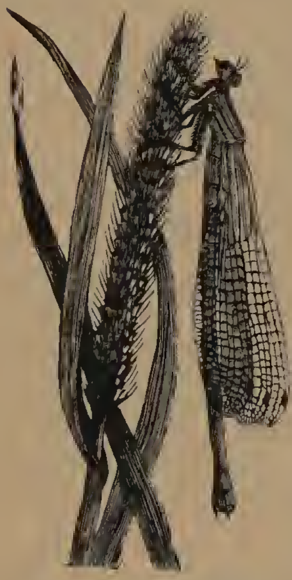

FIG. 128. — A damselfly.

The two pairs of wings of the damselflies are similar in form and are either folded parallel with the abdomen when at rest or are uptilted in a vertical position (Fig. 128). The head is small and the eyes project on each side while the females possess an ovipositor by means of which they place their eggs in the stems of aquatic plants sometimes beneath the water.

Unlike the dragonflies, the damselflies are comparatively slow and feeble of flight although they are graceful in their movements. They are found along the margins of streams and ponds in which the nymphs pass their lives.

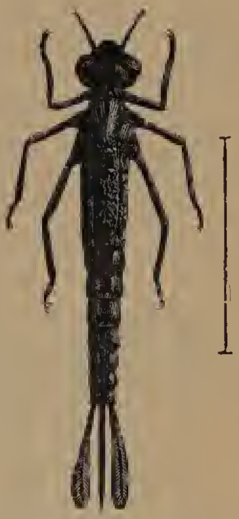

FIG. 129. — Nymph of a damselfly.

Many of the damselflies are very attractive because of their bright blue or green metallic colors.

The nymphs of the damselflies are slender, long-bodied creatures which cling to weeds in the water (Fig. 129). The abdomen is narrow and bears at the caudal end three flat, leaf-like tracheal gills set on edge in a vertical position.

There are two families of the damselflies, the *Agrionidæ* and the *Cœnagrionidæ*.

Family AGRIONIDÆ

Here belong the most beautiful of our damselflies, whose metallic blue or green colors are sure to attract attention. They are feeble in flight and do not go far from the banks of the pond or stream in which they were developed.

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* Zygŏptera: *zygon* (ζυγόν), yoke; *pteron* (πτερόν), a wing.

Family Cœnagrionidæ

The members of this family are easily recognized by the shape of their wings, which are long, narrow, and very distinctly petiolate.

To this family belong the smallest of our damselflies; but while our species are of small or moderate size, there exist in the tropics species that are the largest of the Odonata. Some of our species are dull in color; but many are brilliant, being colored with green, blue, or yellow. This family includes the greater number of our damselflies.

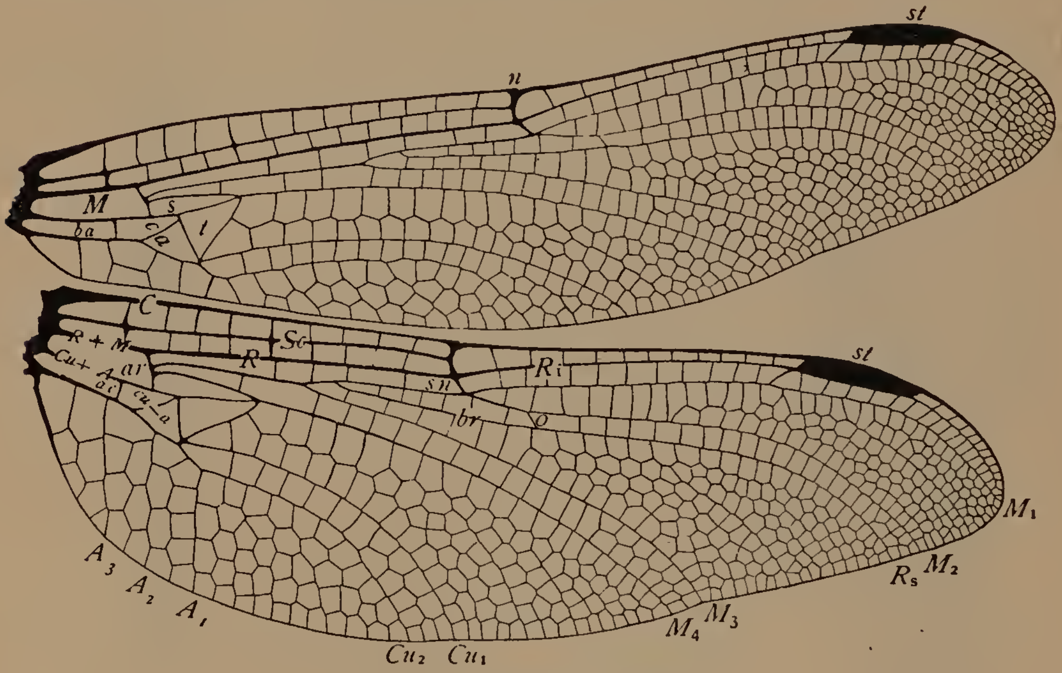

Fig. 129a. — Wings of a dragonfly.

This is an illustration of the fore and hind wings of a dragonfly, enlarged to show the fine network of veins with the *nodus*, *n*, at the middle of the costal margin and the black area near the apex of the wing, known as the *stigma*.

CHAPTER XI

ORDER PLECOPTERA *

The Stoneflies

The members of this order have four membranous wings, with comparatively few or with many cross-veins; in most of the forms the hind wings are much larger than the fore wings, and are folded in plaits and lie upon the abdomen when at rest. The mouth-parts are of the biting type of structure, but are frequently undeveloped in the adults. The metamorphosis is incomplete.

The stoneflies are common insects in the vicinity of rapid streams and on wave-washed rocky shores of lakes; but they attract little attention on account of their inconspicuous colors and secretive habits. They get their name, stoneflies, from the fact that the nymphs are abundant under stones in the beds of streams.

The body of an adult stonefly is flattened and the end of the abdomen in most species, bears two, many-segmented bristles. The antennæ are also long, tapering and many-segmented. The mouth-parts are usually greatly reduced. Indeed, in some, the mandibles are almost membranous and of little use as chewing organs. In other forms they are firm and well fitted for biting. This is especially true of certain species of the genus, *Tæniŏpteryx*. One species of this genus, *T. pacĭfica*, known as the "salmon fly" has become a pest in the Wenatchee Valley in Washington because it eats into the swelling buds of apricots, peaches, and plums and often destroys them.

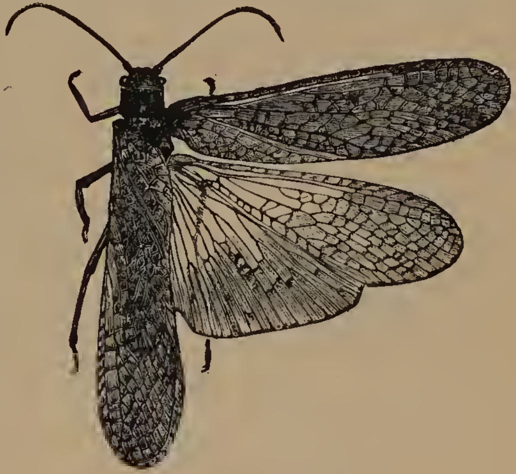

Fig. 130. — A stonefly.

Adult stoneflies are not particularly attractive insects for most of them are of sober hues, black, brown, or gray, although a few which frequent the foliage of plants are green (Fig. 130). As a rule, they are not strong fliers and are usually found crawling about on stones or on plants near streams. Interestingly enough, several of the smaller forms appear early during warm days in February and March while the snow is still on the ground. Several small species formerly of the genus, *Capnia*, but now renamed *Allocăpnia*, are early spring appearing individuals. A very common one, *A. pygmæa*, which is dark brown to black and only about $\frac{1}{4}$ of an inch long, is known as the snow-fly because it appears on the snow during warm days in winter and often enters the house where it may be found crawling on the window-panes.

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* Plecŏptera: *plecos* (πλέκος), plaited; *pteron* (πτερόν), a wing.

The nymphs of stoneflies cling to the undersides of flat stones in swiftly flowing streams. They are flat creatures from one-half inch or less to one and one-half inches in length. They cling so closely and are so nearly the color of the stone that they look almost like fossils. Their antennæ and caudal bristles and three legs on each side extend out like the rays of a star; the six soft clumps of white hair-like gills, one behind each leg, alone show that they are not engraved upon the stone (Fig. 131). These nymphs of the stoneflies are the favorite food of fishes, especially of brook trout. If a nymph is fortunate enough to escape the fate of being a luncheon for fish, when it is full-grown it crawls forth from the water and transforms to an adult stonefly. The cast nymph-skins are common objects on the banks of streams which these insects inhabit.

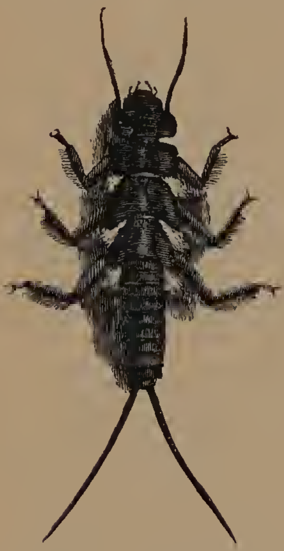
Fig. 131. — Nymph of stonefly.

The tracheal gills of some nymphs are borne either on the underside of the head or on the abdomen while some nymphs possess no tracheal gills whatever, their supply of air being absorbed through the skin.

According to a recent classification of this order, that of Tillyard, it includes seven families; but only four of these families are represented in our fauna. The four families of our fauna can be separated by the following table. Most of our species belong to the Perlidæ.

A. Anal area of the fore wings with two or more series of cross-veins. ....Pteronarcidæ
AA. Anal area of the fore wings with not more than a single series of cross-veins, usually with no cross-veins beyond the basal anal cell.
  B. Media of the fore wings separating from radius gradually, the two forming a sharp angle. ....Perlidæ
  BB. Media of the fore wings separating from radius abruptly, the two forming a blunt angle.
    C. Anal area of the fore wings with a forked vein arising from the basal anal cell. Cerci vestigial. ....Nemouridæ
    CC. Anal area of the fore wings with only simple veins arising from the basal anal cell. Cerci well developed. ....Capniidæ

CHAPTER XII

ORDER CORRODENTIA*

The Psocids and the Book-lice

The winged members of this order have four membranous wings, with the veins prominent, but with comparatively few cross-veins; the fore wings are larger than the hind wings; and both pairs when not in use are placed roof-like over the body, being almost vertical, and not folded in plaits. The mouth-parts are formed for chewing. The metamorphosis is incomplete.

The best-known representatives of this order are the minute, soft-bodied insects which are common in old papers, books, and neglected collections and which have received the popular name of *book-lice*. These low, wingless creatures form, however, but a small part of the order. The more typical winged forms (Fig. 132) bear a strong resemblance to plant-lice or aphids. The body is oval, the head free, and the prothorax small. The fore wings are larger than the hind wings; and both pairs when not in use are placed roof-like over the body, being almost vertical, and not folded in plaits. The mouth-parts are plainly chewing. The mandibles are of the ordinary, strong, heavy, biting type. The maxillæ consist each of a body piece, a weak terminal lobe, and a four-segmented palpus.

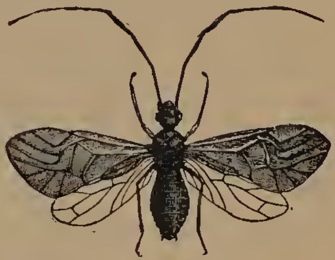

FIG. 132. — *Psocus venosus.*

The venation of the wings is characteristic in this order, see page 84. The venation is more or less reduced; but its most characteristic feature is the bracing of the wing by anastomoses of the principal veins instead of by cross-veins, although there are one or two cross-veins in some species.

The Corrodentia of the United States and Canada represent two families, which can be separated as follows.

A. Wings well developed; ocelli present . . . . PSOCIDÆ
AA. Wings absent or vestigial; ocelli absent . . . . ATROPIDÆ

Family PSOCIDÆ

The Psocids

The family Psocidæ includes the more typical members of the Corrodentia, those in which the wings are well developed (Fig. 132). Usually the wings extend much beyond the end of the abdomen; but short-winged forms occur in species which ordinarily are long-winged. Of course the young of all are wingless, and there is a gradual development as the insect matures.

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* Corrodĕntia: Latin *corrodens*, gnawing.

The psocids occur upon the trunks and leaves of trees, and on stones, walls, and fences. They feed upon lichens, fungi, and probably other dry vegetable matter.

The eggs are laid in heaps on leaves, branches, and the bark of trunks of trees. The female covers them with a tissue of threads, the silk of which is spun from the labium.

Family Atropidæ

The Book-lice and their Allies

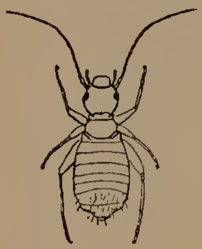

Fig. 133. — A book-louse.

The most commonly observed species of this family are those known as book-lice, which are the minute soft-bodied insects often found in old books (Fig. 133).

Take down from the shelf a time-yellowed book and open its neglected leaves and watch the pale tiny creatures that scurry across its pages; examine one of them with a lens, look well at its alert, knowing, black eyes, and we are sure you will believe that it is in search of real literature and not merely a feeder upon paper, as we are taught. Anyway, scientists have concluded that these insects look wise enough to bear the name *Trŏctes divinatōrius*. Another species with small convex scales representing the front wings is *Ătropos pulsatōria*. It is pale yellowish white and only $\frac{1}{25}$ of an inch in length.

The book-lice feed on the paste in bookbindings, wall-paper and photographs. One species sometimes occurs in enormous numbers in husk or straw mattresses, in which case it is very annoying.

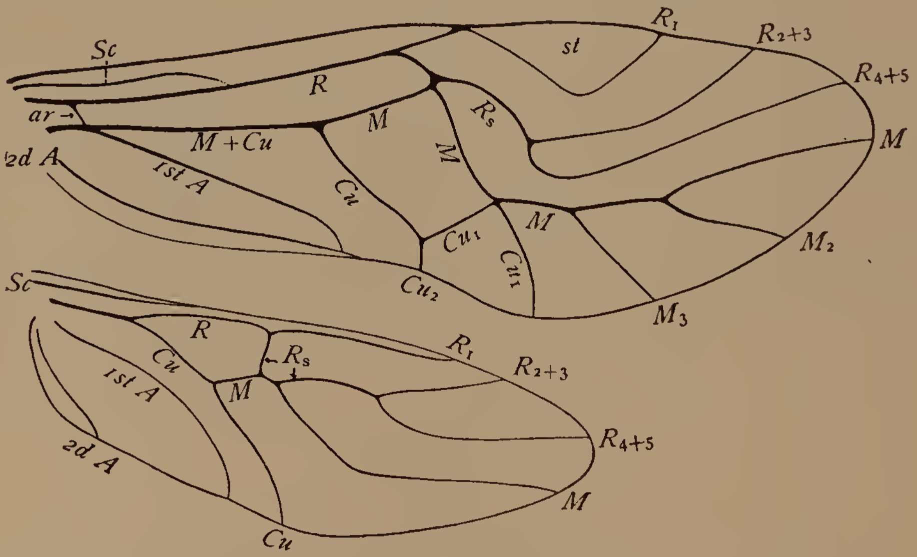

Fig. 133a. — Wings of a psocid.

These enlarged wings of a psocid illustrate the anastomosing of the principal veins, a form of structure which strengthens the wings without the necessity of cross-veins.

CHAPTER XIII

ORDER MALLOPHAGA *

The Bird-lice

The members of this order are wingless parasitic insects with chewing mouth-parts; cerci absent. Their development is without metamorphosis.

The bird-lice are small wingless insects. The more common species range from $\frac{1}{25}$ of an inch to $\frac{1}{5}$ of an inch in length. The bodies of these insects are flattened and usually have broad distinct heads with the antennæ short and either exposed or hidden in grooves on the underside of the head. Bird-lice vary in color from almost white to yellow, tan, brown or nearly black with or without distinctive markings. The mouth-parts are on the underside of the head. The mandibles are large and prominent and the clypeus is enlarged into a conspicuous flap. Degenerate eyes are present on the margins of the head.

The bird-lice resemble the true lice in form and in being parasitic but they feed upon hair, feathers and dermal scales, while the true lice (*Anoplura*) have sucking mouth-parts and feed upon blood.

The Mallophaga infest chiefly birds and on this account the term, bird-lice, is applied to the entire group; a few forms, however, are parasitic upon mammals. For the most part the tarsi of those species that live upon mammals have but one claw which can be clamped against the tibia thus forming a structure well adapted for clinging to hairs. Those species which infest birds have two claws on the tarsi which are better adapted to running among feathers. The white eggs of the bird-lice are glued singly or in groups to the feathers and the development takes place on the body of the host.

Bird-lice injure their hosts through the constant irritation which they cause by feeding on the dermal scales and by scratching the skin with their sharp claws during their incessant movements over the body of the host. It is to free themselves from these pests that birds wallow in dust. When poultry are kept in closed houses they should be provided with a dust bath. In addition the fowls should be treated with a pinch of sodium fluoride on the head, beneath each wing, on the back and underside of the abdomen, and two or three pinches beneath the tail feathers. It has also lately been discovered that nicotine-sulphate smeared on the perches just before the fowls go to roost will destroy all of the lice.

The body-louse of the hen, *Mĕnopon biseriātum*, is the largest louse on the hen; it is about $\frac{1}{10}$ of an inch in length. It is yellowish in color and is found all over the body of the hen and is probably the most serious louse on older chickens and young fowls (Fig. 134). It lays its eggs in clusters at the bases of feathers, especially about the vent of its host.

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* Mallŏphaga: *mallos* (μαλλός), wool; phagein (φαγεῖν), to eat.

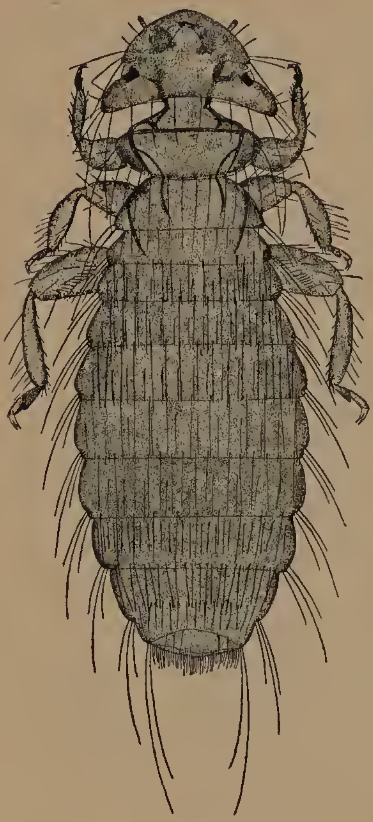

FIG. 134. — The body-louse of the hen.

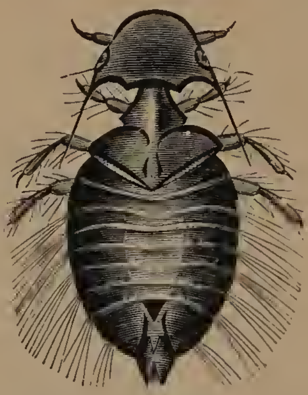

FIG. 135. — *Goniodes stylifer.* (From Law.)

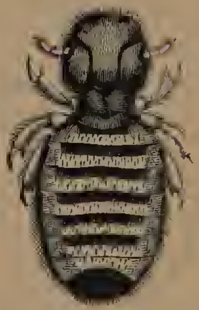

FIG. 136. — *Trichodectes scalaris* (From Law.)

The feather louse, *Mĕnopon păllidum*, is another louse on the hen. It frequents the feathers commonly, although it is found on the skin of its host.

The large turkey louse, *Goniōdes stylifer*, is common on the turkey. It frequents the feathers on various parts of the body, especially on the neck and breast (Fig. 135).

Another and smaller species which infests the ox is known as, *Trichodectes scalaris* (Fig. 136).

CHAPTER XIV

ORDER EMBIIDINA *

The Embiids

This order is composed of small and feeble insects in which the body is elongate and depressed. The winged members of the order have two pairs of wings, which are quite similar in form and structure; they are membranous, extremely delicate, and folded on the back when at rest; the venation of the wings is considerably reduced. The mouth-parts are formed for chewing. Cerci are present and consist each of two segments. The metamorphosis may be considered as incomplete.

This is a small order of insects, only 61 species being listed in a late monograph of the order. Only the males are winged and some species of these are wingless. The wings are usually rather long but have comparatively few veins. Brownish bands run lengthwise of the wings along the courses of the longitudinal veins. The antennæ are filiform and composed of 16 to 32 segments, while ocelli are wanting (Figs. 137 and 138).

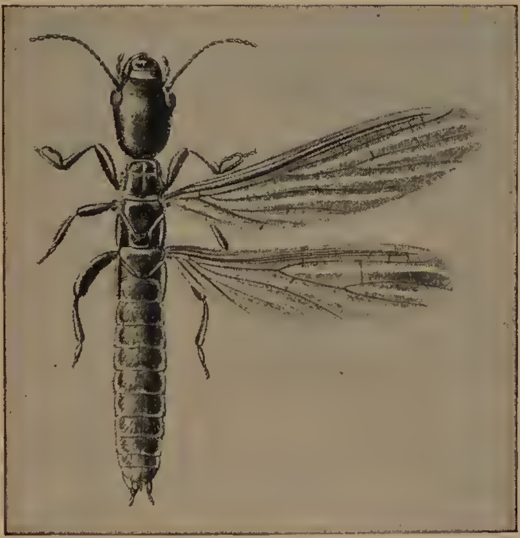

FIG. 137. — *Embia sabulosa*, male. (After Enderlein.)

The metamorphosis of the winged males is more than incomplete and less than complete. It is peculiar because of this intermediate character.

The embiids are small insects and not often seen. They live in silken burrows or galleries made beneath stones or other objects on the ground and sometimes in old decayed logs. Often there is extensive and conspicuous webbing of silk about the haunts and runways of the insects. There seems to be a difference of opinion regarding the position of the silk glands and the source of the silk. Further study of the production of the silk should be made.

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* Embiidina: Embiidæ, *Embia*, *embios* (ἔμβιος), lively.

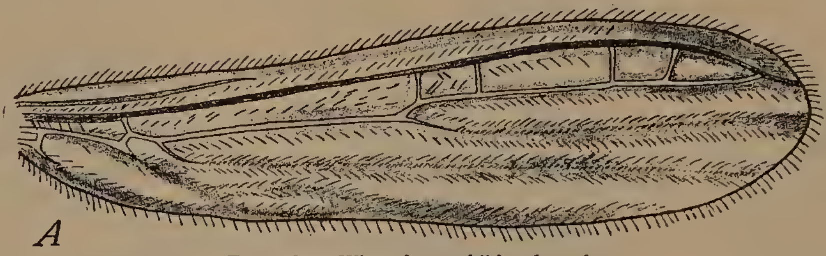

FIG. 138. — Wing of an embiid, enlarged.

The embiids are widely distributed in the warmer parts of the world. A few species have been found in Florida, Texas, and California. They apparently live on decayed organic matter obtained with their chewing mouth-parts.

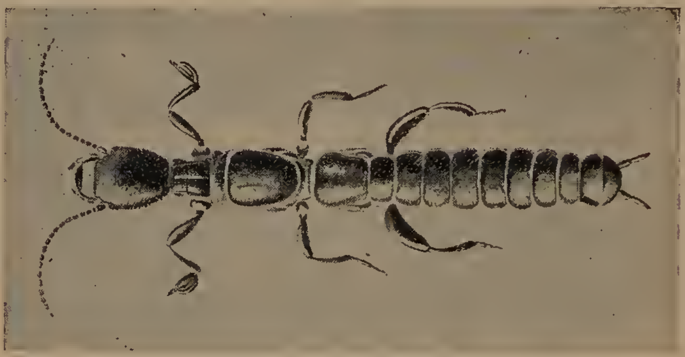

FIG. 138a. — A female embiid.

A female embiid, shown in this illustration, is wingless but has long, slender antennæ. It must be remembered, however, that this insect is very small — it is only about $\frac{3}{5}$ of an inch in length.

CHAPTER XV

ORDER THYSANOPTERA *

The Thrips

The members of this order are minute insects with wings or wingless. The winged species have four wings; these are similar in form, long, narrow, membranous, not plaited, with but few or with no veins, and not commonly with cross-veins; they are fringed with long hairs, and in some species are armed with spines along the veins or along the lines from which veins have disappeared. The mouth-parts are formed for piercing and sucking. The tarsi are usually two-jointed and are bladder-like at the tip. The metamorphosis is incomplete, but deviates from the usual type.

The species of thrips occurring in our fauna are of small size, rarely more than $\frac{1}{12}$ to $\frac{1}{8}$ of an inch in length. They can be obtained easily, however, from various flowers, especially those of the daisy and clover. Ordinarily it is only necessary to pull apart one of these flowers to find several thrips. They are in many cases very active insects, leaping or taking flight with great agility.

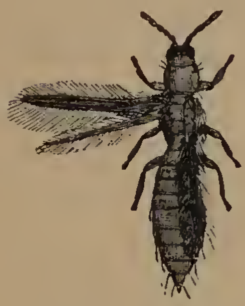

Fig. 139. — *Thrips.*

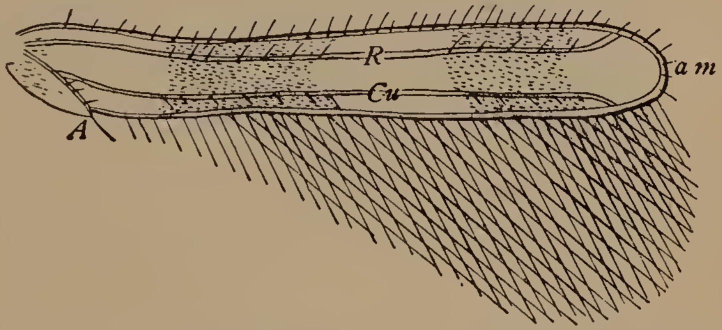

Fig. 140. — Fore wing of *Ælothrips nasturtii.* (After Jones.) The lettering is original.

The body is long (Fig. 139). The antennæ are filiform or moniliform and consist of from six to nine segments; they are always longer than the head and may be two or three times as long. The compound eyes are large, with conspicuous facets, which are circular, oval, or reniform in outline. Three ocelli are usually present in the winged forms. The mouth-parts are fitted for piercing and sucking; they are in the form of a cone which encloses the piercing organs. The cone is composed of the clypeus, labrum, maxillary sclerites, and labium. The piercing organs consist of the left mandible (the right mandible is vestigial) and the two maxillæ. The mouth-parts of the Thysanoptera bear a striking resemblance to those of the Hemiptera. The wings are laid horizontally on the back when not in use; they are very narrow, but are fringed with long hairs (Fig. 140). The fringing of the wings suggested the name Thysanoptera.

* Thysanŏptera: *thysanos* (θύσανος), fringe; *pteron* (πτερόν), a wing.

In some species one or both sexes are wingless in the adult state; and in others, short-winged forms occur. The cerci are absent.

The legs are well developed, but are furnished with very peculiar tarsi. These are usually composed of two segments; the last segment terminates in a cup-shaped or hoof-like end and is usually without claws. Fitted into the cup-shaped end of the tarsus there is a very delicate, protrusile, membranous lobe or bladder, which is withdrawn into the cup when not in use but is protruded when the tarsus is brought into contact with an object. This is one of the most distinctively characteristic features of the members of this order. It was this feature that suggested the name Physopoda which is applied to this order by some writers.

In one suborder, the *Terebrantia*, the female has a saw-like ovipositor with which she cuts slits in the tissues of plants and then deposits her eggs therein. In the other suborder, the *Tubulifera*, the female does not have a saw-like ovipositor and evidently deposits her eggs on the surfaces of objects.

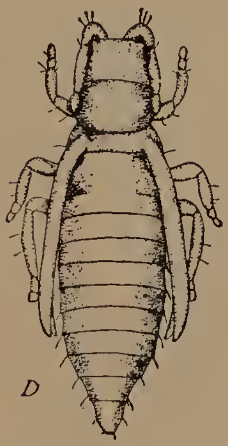

Fig. 141. — Last nymphal stage of a thrips.

The metamorphosis of thrips is interesting because it approaches in some respects the type of complete metamorphosis. There is a quiescent stage resembling a pupa preceding the imago (Fig. 141).

The different species of thrips vary greatly in habits, some being injurious to vegetation, while others are carnivorous, feeding on aphids and other small insects, the eggs of insects, and mites, especially the "red spider." Their most important economic rôle, however, is that of pests of cultivated plants. The thrips that infest plants puncture the tissue of the plant by their piercing mouth-parts and suck out the sap.

Suborder TEREBRANTIA

Among those thrips having saw-like ovipositors are found the more important economic species. The onion thrips, *Thrips tabaci*, is seriously injurious to onions, and often attacks cucumbers, tobacco, cabbage, and cauliflower.

The greenhouse thrips, *Helĭothrips hæmorrhoidalis*, is a tropical insect, which is often a serious pest in greenhouses; it is also found out of doors in the milder California climate.

The bean thrips, *Helĭothrips fasciātus*, is a serious pest on oranges, alfalfa, pear trees, and various garden crops in California.

The orange thrips, *Scĭrtothrips citri*, is a serious orange pest in California and Arizona; it deforms the new growth of foliage and causes scabbing and scarring of the fruits.

The pear thrips, *Tæniothrips incŏnsequens*, infests pears, prunes, peaches, and other deciduous fruits, both in California and in the East. It infests the opening buds and blossoms, stunting the leaves and blasting the blossoms.

The strawberry thrips, *Franklĭniella tritici*, was first described as a pest of wheat. It is found in the flowers of almost all wild and cultivated plants and is the commonest and most widely distributed of all American species of thrips. It is especially injurious to the strawberry.

Suborder TUBULIFERA

Those thrips which lack the saw-like ovipositor are not of great economic importance in our country, at least. One of the more common forms is the mullein thrips, *Neoheegēria verbasci*, the black individuals of which may usually be found in numbers during the fall among the rosettes of woolly leaves of our common mullein.

The camphor thrips, *Crȳptothrips floridĕnsis*, is particularly abundant in Florida, where it is injurious to the camphor tree, especially to those individuals that have been cut back or pruned severely.

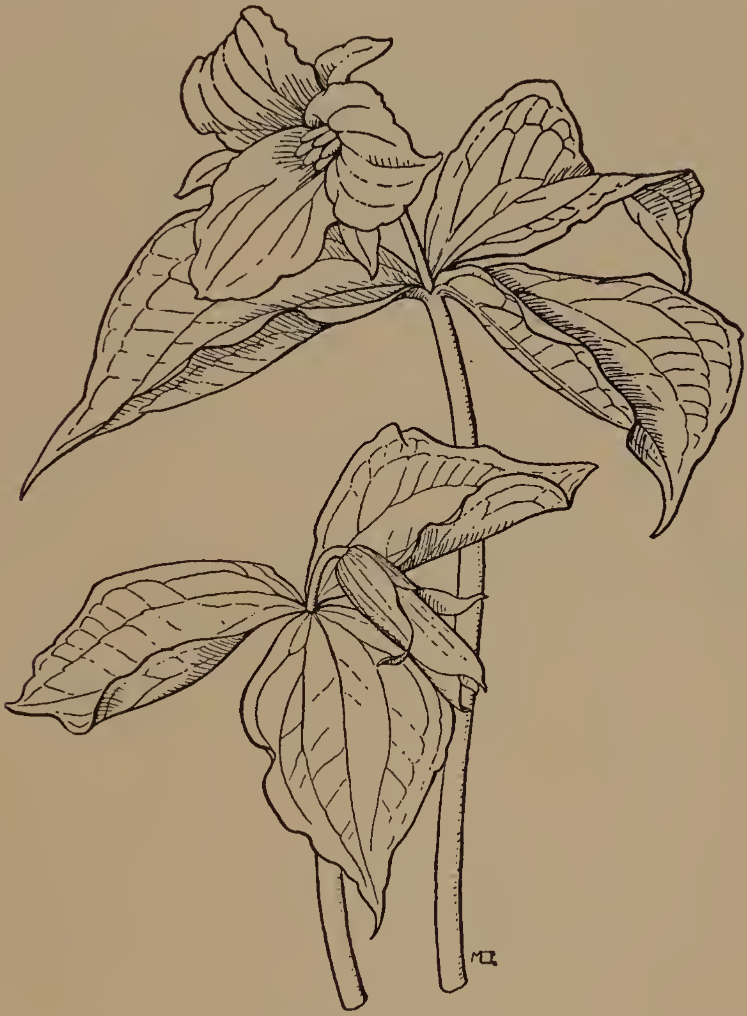

Fig. 141a. — Trillium.

One of our fine, large species of thrips, *Ctenothrips bridwelli*, is found on trillium and mandrake.

5.67 7.67

860-6770
341-2460

9.15

CHAPTER XVI

ORDER ANOPLURA *

The True Lice

The members of this order are wingless parasitic insects with piercing and sucking mouth-parts. Their development is without metamorphosis. Cerci absent.

The order Anoplura is composed of the true lice. These are small wingless insects, which live on the skin of mammals and suck their blood. They are sharply distinguished from the Mallophaga or bird-lice by the possession of piercing and sucking mouth-parts.

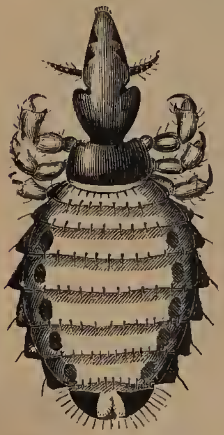

FIG. 142.— Louse of the horse. (From Law.)

The body is more or less flattened (Fig. 142). The head is free and horizontal. The compound eyes are vestigial or are wanting. There are no ocelli. The antennæ are three-, four-, or five-jointed. The mouth is furnished with a fleshy, unjointed proboscis, which can be withdrawn into the head or extended to a considerable length. Within this proboscis are two knife-like stylets; and at its base, when extended, there is a wreath of recurved hooks. These hooks serve to anchor firmly the proboscis when inserted in the skin of the infested animal.

There is a single tarsal claw, which is opposed by a toothed projection of the tibia, forming an efficient organ for clinging to the hairs of the host. The abdomen consists of nine segments; there are no cerci.

The eggs of the true lice are commonly known as "nits." They are attached to the hairs of the host by a glue-like substance. The young lice resemble the adults except in size.

The order *Anoplura* is a small one of not more than 100 species at the present time. The most familiar forms are those infesting man and the domestic animals, horses, cows, sheep, swine, dogs and cats.

The three species of lice parasitic on man belong in the family Pediculidæ. They have comparatively large, convex, pigmented eyes and the proboscis is short.

The most common species on man is the head-louse, *Pedĭculus căpitis*. It lives among the hairs of the head and attaches its white eggs, or "nits" to the hairs. It is most common on the heads of children who live under unsanitary conditions.

The body-louse, *Pedĭculus cŏrporis*, (Fig. 143), lives on the body, especially on the chest and back. It increases enormously among soldiers who are unable to bathe frequently. During the world war the "cooties," as the soldiers called them, were extremely troublesome. They laid their eggs on threads of the clothing but it was found that both lice and eggs were destroyed during a proper laundering process.

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* Anoplūra: *anoplos* (ἄνοπλος), unarmed; *oura* (οὐρά), tail.

The crab-louse, *Phthĭrius pūbis*, which is nearly as broad as long, lives in the armpits and pubic regions of the body.

The common lice on cattle, swine, dogs and cats belong to the family *Hæmatopinidæ*. These lice have long probosces and the eyes are vestigial or wanting. The short-nosed ox-louse, *Hæmatopīnus eurystĕrnus*, (Fig. 144) is found principally on the neck and shoulders of mature cattle. It is of a bluish-slate color and about $\frac{1}{8}$ of an inch long. Sodium fluoride applied to the infested places with a tin shaker and then rubbed in among the hairs with the hand is an effective remedy for these cattle-lice.

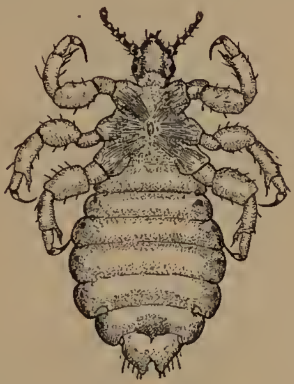
FIG. 143. — The body louse, *Pediculus corporis*, much enlarged.

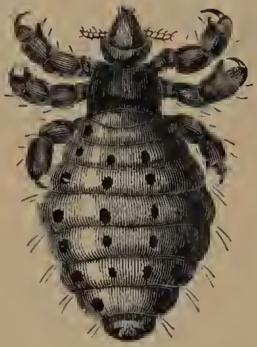
FIG. 144. — *H. eurysternus*. (From Law.)

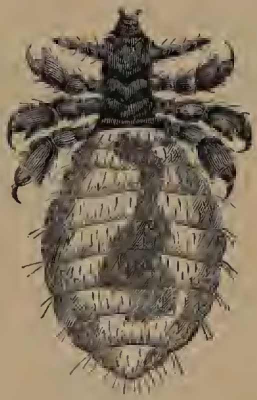
FIG. 145. — The dog-louse. (From Law.)

The dog-louse, *Linŏgnathus pilĭferus*, has a broad abdomen and a comparatively short proboscis (Fig. 145). The hog-louse, *Hæmatopinus suis*, is the largest louse affecting domestic animals and is common on swine, especially if their quarters are neglected and allowed to become unreasonably filthy.

CHAPTER XVII

ORDER HEMIPTERA *

The True Bugs

The winged members of this order have four wings; the wings of the first pair are thickened at the base, with thinner extremities which overlap on the back. The mouth-parts are formed for piercing and sucking; the beak arises from the front part of the head. The metamorphosis is incomplete.

People who know but little regarding entomology are apt to apply the term *bug* to any kind of insect; but strictly speaking, only members of the order Hemiptera are bugs.

The bugs are very common insects. Many species abound on grass and on the foliage of other plants; some species live on the surface of water; others live within water; and a few are parasitic on birds and mammals.

This order is a very important one; it includes many species injurious to vegetation; among these are some of our more important pests of cultivated plants. On the other hand, some of the species are ranked among beneficial insects on account of their predacious habits; for many of them feed upon noxious insects.

The name Hemiptera was suggested by the form of the front wings. In these the basal half is thickened so as to resemble the elytra of beetles, only the terminal half being wing-like. The hind wings are membranous, and are folded beneath the front wings. On this account the front wings are often termed *wing-covers;* they are also termed *hemelytra*, a word suggested by their structure.

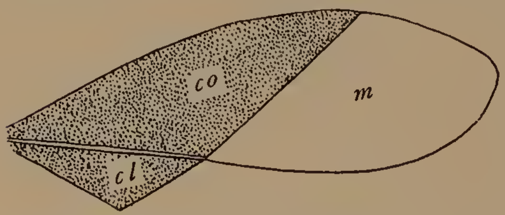

FIG. 146. — Diagram of a front wing of a bug: *cl*, clavus; *co*, corium; *m*, membrane.

In the Hemiptera the front wings present characters much used in the classification of these insects; and consequently special names have been applied to the different parts of them. The thickened basal portion is composed of two pieces joined together at their sides; one of these is narrow and is the part next to the scutellum when the wings are closed; this is distinguished as the *clavus* (Fig. 146, *cl*); the other part is the *corium* (Fig. 146, *co*). The terminal portion of the front wing is termed the *membrane* (Fig. 146, *m*). In certain families, the Anthocoridæ for example, a narrow piece along the costal margin of the wing is separated by a suture from the remainder of the corium; this is the *embolium* (Fig. 149, *e*). In certain other cases, as the Miridæ for example, a triangular portion of the terminal part of the corium is separated as a distinct piece; this is the *cuneus* (Fig. 148, *cu*).

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* Hemĭptera: *hemi-* (ἡμι), half; *pteron* (πτερόν), a wing.

The mouth-parts are formed for piercing and sucking. Without dissection, they usually appear as a slender segmented beak arising from the front part of the head (Fig. 149). The beak consists of the labium with possibly vestiges of the labial palpi combined with it. The beak is deeply grooved on the dorsal surface forming a channel in which are four long, slender setæ or bristles, two of which are the much modified mandibles and two the greatly changed maxillæ. The beak is not a piercing organ; its function is to protect and direct the setæ and to determine, by means of tactile hairs at its tip, the place where the puncture should be made by the setæ (Fig. 150).

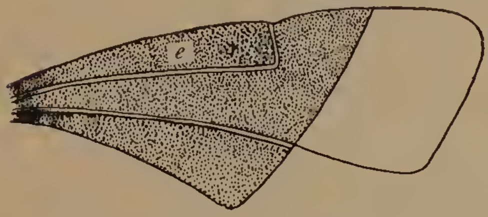

FIG. 147. — Diagram of a front wing of an anthocorid: *e*, embolium.

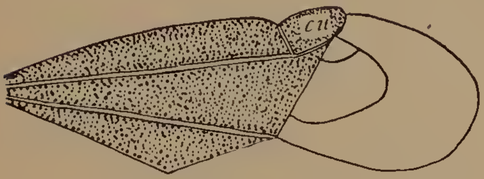

FIG. 148. — Diagram of a front wing of a mirid: *cu*, cuneus.

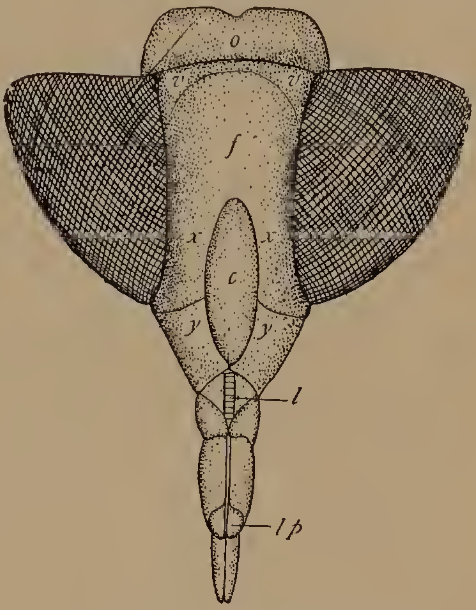

FIG. 149. — Head of *Lethocerus*: *c*, clypeus; *l*, labrum; *lp*, labial palpi; *y*, *y*, maxillary sclerites.

The mandibular and maxillary setæ when in use, are pushed beyond the tip of the beak in order to pierce the tissues of the plant on which the insect is feeding.

Most of the Hemiptera protect themselves by the emission of a fluid having a disagreeable odor. In the stink-bugs, *Pentatomidæ*, the fluid is excreted through two openings on the ventral side of the thorax near the middle coxæ. In the bedbugs the openings are in the dorsal wall of the first three abdominal segments.

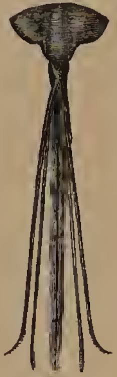

FIG. 150. — Mouth-parts of Bug. (After Muhr.)

In the Hemiptera the metamorphosis is incomplete; the newly-hatched young resembles the adult in the form of its body but lacks wings. After one or two molts the wing-buds appear and become larger and larger at successive molts. With the last molt there takes place a great expansion of the wings, the change at this time being much greater than at either of the previous molts. There are many wingless forms in this order. In some species all individuals are wingless; in others there are two forms of adults, the winged and the wingless.

TABLE FOR DETERMINING THE FAMILIES OF THE HEMIPTERA

A. Antennæ shorter than the head, and nearly or quite concealed in a cavity beneath the eyes.
B. Hind tarsi with indistinct setiform claws (except in *Plea*, of the family Notonecitidæ, which are less than 3 mm. in length).
C. Fore tarsi consisting of one segment, which is flattened or shovel-shaped, and without claws; head overlapping the prothorax dorsally. p. 97.... CORIXIDÆ
CC. Fore tarsi of the usual form, and with two claws; head inserted in the prothorax. p. 98.................................... NOTONECTIDÆ
BB. Hind-tarsi with distinct claws.
C. Caudal end of the abdomen furnished with a respiratory tube composed of a pair of grooved, thread-like organs; tarsi one-segmented. p. 98.... NEPIDÆ
CC. Caudal end of abdomen without long respiratory tube.
D. Legs flattened, fitted for swimming; caudal end of the abdomen furnished with a pair of strap-like appendages (these appendages are retractile and are frequently withdrawn from sight); tarsi two-segmented. p. 99.................................... BELOSTOMATIDÆ
DD. Legs fitted for walking; abdomen without strap-like caudal appendages.
E. Without ocelli. p. 107 .... NAUCORIDÆ
EE. Ocelli present. p. 100.............................. GELASTOCORIDÆ
AA. Antennæ at least as long as the head, usually free, rarely (*Phymatidæ*) fitting in a groove under the lateral margin of the pronotum.
B. Body linear; head as long as the three thoracic segments. p. 107.................................... HYDROMETRIDÆ
BB. Body of various forms, but, when linear, with the head shorter than the thorax.
C. Last segment of the tarsi more or less split, and with the claws of at least the front tarsi inserted before the apex.
D. Hind femora extending much beyond the apex of the abdomen; the middle and hind pairs of legs near together and very distant from the front pair; beak four-jointed. p. 101.......................... GERRIDÆ
DD. Hind femora not extending much beyond the apex of the abdomen; middle pair of legs about equidistant from front and hind pairs (except in *Rhagovelia*); beak three-jointed. p. 101.......................... VELIIDÆ
CC. Last segment of the tarsi entire, and with the claws inserted at the apex.
D. Antennæ four-jointed.*
E. Hemelytra resembling network, and very rarely with any distinction between the corium and the membrane. p. 104................ TINGIDÆ
EE. Hemelytra of various forms or absent, but not of the form presented by the Tingidæ.
F. Beak three-jointed.
G. Hemelytra when well developed with an embolium (Fig. 147); those forms in which the adult has vestigial hemelytra have no ocelli.
H. Hemelytra vestigial; parasitic bugs preying on man, bats, and birds. p. 102.................................... CIMICIDÆ
HH. Hemelytra usually well developed; not parasitic bugs. p. 102.................................... ANTHOCORIDÆ
GG. Hemelytra when well developed without an embolium; those forms in which the adult has vestigial hemelytra have ocelli.
H. Ocelli wanting.
I. Body greatly flattened. p. 108.......................... ARADIDÆ
II. Body not greatly flattened. p. 103.................. REDUVIIDÆ
HH. Ocelli present, though sometimes difficult to see.
I. Beak long, reaching to or beyond the intermediate coxæ; antennæ not whip-like; membrane of hemelytra with looped veins. p. 100.................................... SALDIDÆ
II. Beak not reaching the intermediate coxæ.
J. Front legs with greatly thickened femora. p. 104.. PHYMATIDÆ
JJ. Front femora somewhat thickened, but much less than half as wide as long. p. 103.......................... REDUVIIDÆ

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* In some cases there are minute intermediate joints between the principal joints of the antennæ; for the purposes of this table these intermediate joints are not counted.

FF. Beak four-jointed.
  G. Front legs fitted for grasping prey, the tibiæ being armed with spines and capable of being closed tightly upon the femora, which are stout. In the forms with long wings the membrane is usually furnished with four long veins, bounding three discal cells which are often open. From these cells diverge veins which form several marginal cells (Fig. 165). p. 103........................NABIDÆ
  GG. Front legs fitted for walking.
    H. Hemelytra with cuneus; membrane with one or two closed cells at its base; tarsi furnished with an arolium. p. 101....MIRIDÆ
    HH. Hemelytra without cuneus. Membrane with four or five simple or anastomosing veins arising from the base; or with a large number of veins arising from a cross-vein at the base.
      I. Ocelli wanting.
        J. Exceedingly flat bugs. p. 108......................ARADIDÆ
        JJ. Rather stout and heavily formed bugs. p. 104 ....PYRRHOCORIDÆ
      II. Ocelli usually present.
        J. Head with a transverse incision in front of the ocelli, which are always present. p. 107......................NEIDIDÆ
        JJ. Head without transverse incision.
          K. Membrane with four or five simple veins arising from the base of the membrane, the two inner ones sometimes joined to a cell near the base (Fig. 173). p. 105.......... ....LYGÆIDÆ
          KK. Membrane with many, usually forked veins, springing from a transverse basal vein (Fig. 175). p. 106.......... ....COREIDÆ

DD. Antennæ five-jointed.*
  E. Tibiæ armed with strong spines; hemelytra with the clavus markedly thicker than the membrane. p. 108.........................CYDNIDÆ
  EE. Tibiæ smooth or with small spines.
    F. Scutellum narrowed behind, only rarely almost covering the abdomen. p. 106...PENTATOMIDÆ
    FF. Scutellum not narrowed as in the Pentatomidæ, very convex, nearly or quite covering the abdomen. p. 108................SCUTELLERIDÆ

* In some cases there are minute intermediate joints between the principal joints of the antennæ; for the purposes of this table these intermediate joints are not counted.

Family CORIXIDÆ

The Water-boatmen

The family Corixidæ includes oval, gray-and-black mottled bugs, usually less than half an inch in length, which live in lakes, ponds, and streams, in both stagnant and running water. The characteristic form and markings of these insects are shown in Figure 151.

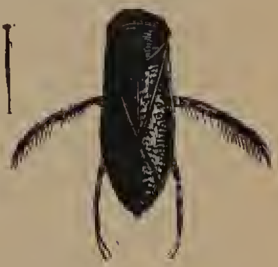

FIG. 151. — A water-boatman.

The beak is very short, the middle legs are very long and slender, and end in two claws, while the hind legs are long, flattened and fringed for swimming. The water-boatmen have the body flattened on the dorsal side and they swim on the ventral side in normal position.

The body of these insects, as they swim through the water, is almost completely enveloped in air, which glitters like a silver armor. This air is purified by contact with the fine particles of air scattered through the water; so that the insects can breathe their coats of air again and again if they are in clean water. If the insects are in stagnant water they have to come to the surface at intervals for a fresh supply of air.

In their favorite attitude the water-boatmen are anchored to some object near the bottom of the water by their long middle legs. The body of these insects, with the air which clings to it, is much lighter than water; consequently whenever they lose hold upon the object to which they have been clinging, they rise quickly to the surface, unless they prevent it by swimming. They occasionally float on the surface of the water, and can leap into the air from the water and take flight.

These insects feed upon the vegetable matter in the ooze at the bottoms of ponds and at the same time consume the minute animals which are present in this plant material.

Both the adults and eggs of species of the genus *Corixa* are used as food for man and for birds. It is said that in Mexico the natives bind the stalks of a sedge into bundles which are then floated on the water of a lake where the bugs will deposit their eggs on them in great abundance. The bundles are then removed and dried and the eggs beaten off on to a cloth and then ground into flour for baking. The adults and eggs of *Corĭxa mercenāria* are said to be imported into England by the ton as food for birds, game, and fish.

Family NOTONECTIDÆ

The Back-swimmers

The back-swimmers have the back shaped like the bottom of a boat instead of being flat like that of the water-boatmen and they differ from all other aquatic bugs in that they always swim on their backs.

The favorite attitude of the back-swimmers is floating on the surface of the water, back downward, with the hind end of the body projecting sufficiently to admit of air being drawn into two air chambers on the ventral side of the body. There are two longitudinal furrows on the ventral side of the abdomen arched over by long hairs thus forming two tubes into which air is taken. The spiracles open into these tubes.

The hind legs are long and act as oars and when the back-swimmers are disturbed they dart away toward the bottom of the pond. They do, however, lie right side up on the surface of the water occasionally and often take flight into the air.

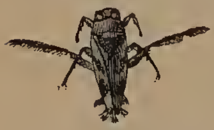

FIG. 152. — A back-swimmer.

The species of the genus, *Notonecta*, are most common (Fig. 152). They have sharp piercing mouth-parts and sometimes sting with them unless handled carefully.

Family NEPIDÆ

The Water-scorpions

The water-scorpions have two long filaments on the end of the body, which are grooved on the inner side. By putting these filaments together a long tube is formed, which the insects can project to the surface of the water, and thus obtain air for breathing, while resting on the bottom of the pond. This tube conducts the air to two spiracles at the caudal end of the abdomen.

The most common members of this family belong to the genus *Ranatra* (Fig. 153). These are long, slender bugs with long, slender legs. The only other representative of the family found in the United States is *Nēpa apiculāta.* In this species the body is oval, flat, and thin, and measures about two-thirds of an inch in length, not including the breathing-tube (Fig. 154).

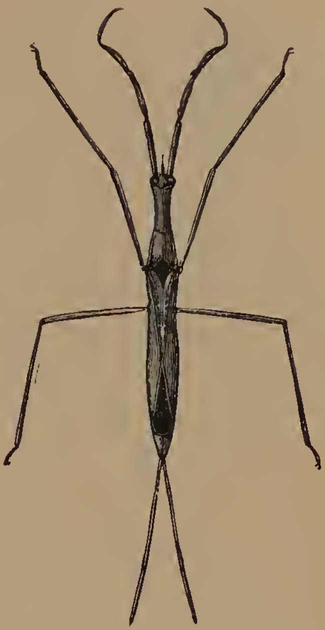

Fig. 153. — A water-scorpion.

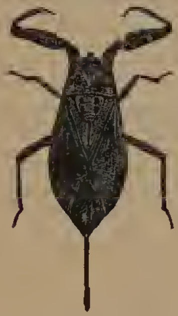

Fig. 154. — *Nepa apiculata.*

The water-scorpions live among rubbish or on the stems of water-plants, in ponds and in the quiet parts of our streams. They are carnivorous, and have the first pair of legs fitted for seizing prey. In these legs the coxa is very long, and the femur is furnished with a groove into which the tibia and tarsus fit like the blade of a pocket-knife into the handle.

The eggs of these bugs are inserted in the decaying tissues, often stems, of aquatic plants. Although these insects are aquatic the second and hind pairs of legs are fitted for walking rather than for swimming.

Family Belostomatidæ

The Giant Water-bugs

The common name "giant water-bugs" was applied to this family because it contains the largest of the Hemiptera now living.

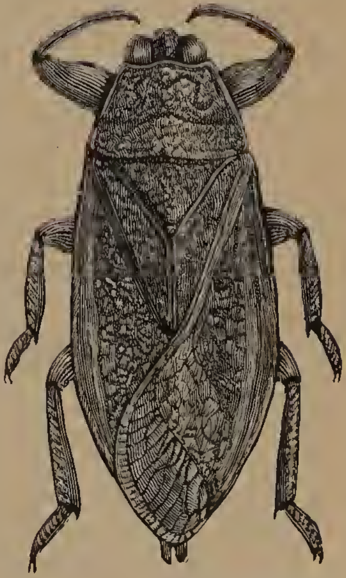

Fig. 155. — *Lethocerus americanus.*

The members of this family are all wide and flat-bodied aquatic insects. The fore legs are for grasping, the middle and hind legs are fitted for swimming. At the caudal end of the body there is, in the adult, a pair of narrow, strap-like respiratory appendages, which are retractile.

These insects are rapacious creatures, feeding on other insects, snails, and small fish. Like other water-bugs, they fly from pond to pond and are frequently attracted to lights. This is especially the case where electric lights are used, into which they sometimes fly and are killed by hundreds. On this account they are known in many parts of the country as "electric-light bugs."

Figure 155 represents *Lethŏcerus americānus.* In Lethocerus, the front femora are grooved for the reception of the tibiæ, as in the pre-

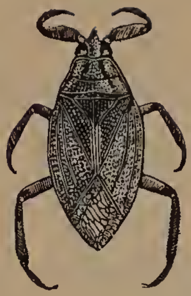

FIG. 156. — *Belostoma fluminea.*

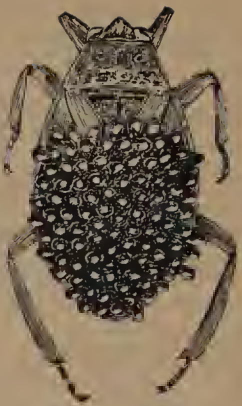

FIG. 157. — Eggs on back of *Abedus.*

ceding family. Another common representative of the family is *Benăcus grĭseus.* This resembles *Lethocerus americanus* very closely but can be distinguished from it by the absence of the femoral groove.

There are other smaller species of this family which belong to the genus *Belostoma.* Our most common species is *Belŏstoma flumĭnea* (Fig. 156).

In this genus and in *Abēdus* the eggs are carried by the males on their backs, where they are placed by the females, sometimes in spite of vigorous opposition on the part of the male (Fig. 157).

Family GELASTOCORIDÆ

The Toad-shaped Bugs

The Gelastocŏridæ was formerly known as the Galgulidæ.

In these insects the body is broad and short, and the eyes are prominent and projecting; the form of the body and the protuberant eyes remind one of a toad (Fig. 158). Ocelli are present. The antennæ are short and nearly or quite concealed beneath the eyes. The beak is short, stout, and four-segmented. The fore legs are raptorial.

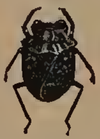

FIG. 158. — *Gelastocoris oculatus.*

The toad-shaped bugs live on the muddy margins of streams or other bodies of water. Some of them make holes for themselves, and live for a part of the time beneath the ground. They feed upon other insects, which they capture by leaping suddenly upon them. Their colors are protective and vary so as to agree with the color of the soil on which they live. The eggs are buried in the sand.

The most common and most widely distributed representative of the family found in this country is *Gelastŏcoris oculātus* (Fig. 149).

Family SALDIDÆ

The Shore-bugs

These are certain small bugs, of dark colors with white or yellow markings, which abound in the vicinity of streams and lakes, and upon damp soils, especially of marshes near our coasts. The shape of these shore-bugs is shown by Figure 159. The antennæ are long and conspicuous. The beak is three-segmented and very long.

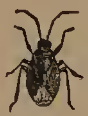

FIG. 159. — A shore-bug.

Some of the shore-bugs dig burrows, and live for a part of the time beneath the ground. They take flight quickly when disturbed, but alight after flying a short distance, taking care also to slip quickly into the shade of some projecting tuft of grass or clod where the soil agrees with the color of their bodies.

Thirty-three species belonging to this family have been found in the United States and Canada; these represent eight genera.

Family VELIIDÆ

The Broad-shouldered Water-striders

The Veliidæ includes insects which are closely related to the water-striders of the next family. The bodies of these insects are usually stout, oval and broadest across the prothorax. The legs are not extremely long and the second pair is about equidistant from the front and hind pairs except in the genus *Rhagovēlia* (Fig. 160).

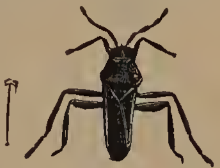
FIG. 160. — *Rhagovelia.*

The broad-shouldered water-striders are found both on the banks of streams and ponds and on the surface of the water. The small, plump-bodied species of *Microvēlia* are found at the water's edge but run out on the water when disturbed. Those of *Rhagovelia* which are larger, run on the surface of rapid streams.

These water bugs are dimorphic, for both fully winged and short-winged to wingless adults occur in the same species.

Family GERRIDÆ

The Water-striders

On the quiet pools of streams or calm waters of ponds one may usually find numbers of rather long-bodied insects with long slender legs, skimming about over the surface of the water. These are the true water-striders. The long middle and hind legs are near together and distant from the front legs (Fig. 161). It should be noted that some water-striders have comparatively short oval bodies.

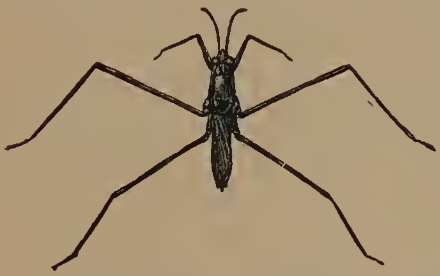
FIG. 161. — A water-strider.

These insects are predacious and feed on other insects which happen to fall in the water; they often jump from the water to capture flies. In the fall, the water-striders hide away beneath the banks of the streams or at the bottoms of the pools and there they remain until spring.

There are commonly winged and wingless forms of the same species. Thus these insects are dimorphic.

Twenty species of water-striders are known from our fauna and those of the genus, *Halŏbates*, are deep sea forms for they live on the surface of the ocean, often hundreds of miles from land.

Family MIRIDÆ

The Leaf-bugs

This family, formerly known as the Capsidæ, is the largest family of the Hemiptera. The species are small or of medium size but they vary greatly in form and markings. The hemelytra are rather characteristic for they are nearly always complete with clavus, corium, cuneus and membrane. The family contains several well-known economic forms.

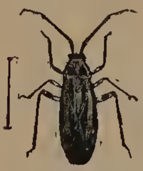

Fig. 162. — *Pœcilocapsus lineatus.*

The four-lined leaf-bug, *Pœcilocăpsus lineātus*, is a bright, yellow bug about $\frac{1}{3}$ of an inch long, with four longitudinal black lines along its back (Fig. 162). It attacks various plants but is most injurious to currants, gooseberries, deutzia, dahlia, and weigelia. Its eggs are laid in groups of 6 to 8 in the stems of the food plants. There is one generation each year.

The tarnished plant bug, *Lȳgus pratĕnsis*, is a greenish to dull brown bug about $\frac{1}{5}$ of an inch long with a V-shaped yellowish mark on the scutellum. It has been recorded on about fifty different plants and is often seriously injurious to asters, dahlias, and celery and to apple and peach trees in the nursery row. No satisfactory method of control is yet known.

The apple redbug, *Lygĭdea mĕndax*, is another injurious species of this family. The nymphs are bright red in color but the adults are lighter and not so conspicuous. Both the nymphs and adults puncture the young apples with their beaks, thereby causing the fruit to become knotty, deformed and misshapen. The bugs can be controlled by spraying the trees after the petals have fallen with nicotine-sulphate at the rate of $\frac{3}{4}$ of a pint to 100 gallons of water.

Family Anthocoridæ

The Flower-bugs

The flower-bugs are small insects living on flowers, often on trees and sometimes under bark or rubbish. They are predacious and happily some of them prey upon injurious species of insects. The most common one is the insidious flower-bug, *Trīphleps insidiōsus*, which is black and only about $\frac{1}{12}$ of an inch in length. It is common on flowers as well as in other situations. It preys on Phylloxera on the leaves of grapes and sometimes on the chinch-bug.

Family Cimicidæ

The Bedbug Family

The members of this family are parasitic bugs, which are either wingless or possess only vestigial hemelytra. In these insects the ocelli are absent, the antennæ are four-jointed, the beak is three-jointed, and the tarsi are three-jointed. Only four species belonging to this family have been found in America north of Mexico. These are the bat bedbug, *Cīmex pilosĕllus*, which is parasitic on the bat, the species found in the nests of swallows, *Œciacus vicārius*, the species which infests poultry in the Southwest, *Hæmatosīphon inōdorous*, and the common bedbug, *Cīmex lectulārius*, which sometimes attacks poultry as well as man. The bedbug is a well-known pest over the greater part of the world. It is reddish brown in color, and measures when full-grown from one-sixth to one-fifth inch in length. The body is ovate in outline and very flat (Fig. 163). It is wingless, or has very short vestigial hemelytra.

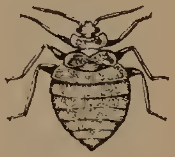

Fig. 163. — A bedbug.

The begbug is nocturnal in habits, hiding by day in the cracks of furniture and beneath various objects. The white oval eggs are laid in batches in cracks and crevices of bedsteads and furniture, under seams of mattresses and in other places. They hatch in from six to ten days and the nymphs, under favorable conditions, become grown in 35 to 48 days. In well-heated houses the bugs will multiply all the year round.

Family NABIDÆ

The Nabids

In this family the body is oblong and somewhat oval behind. In some species there are two forms, a short-winged and a long-winged form. In case of one of the most common species, *Nābis subcoleoptrātus*, the short-winged form (Fig. 164), in which the hemelytra barely reach to the second abdominal segment, is much more abundant than the long-winged form. It is of a shining jet-black color with yellowish legs.

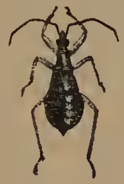

Fig. 164. — *Nabis subcoleoptratus.*

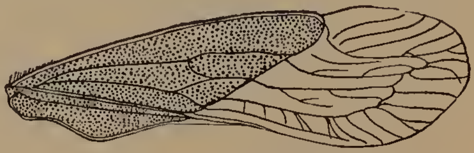

Fig. 165. — Hemelytron of *Nabis ferus.*

Family REDUVIIDÆ

The Assassin-bugs

This is a large family containing bugs of very diverse form. They are predacious on other insects and sometimes on the higher animals, even attacking man. The beak is three-segmented and very efficient as a puncturing instrument.

The masked bedbug hunter, *Redūvius personātus*, has become notorious as a "kissing bug" for it often inflicts painful wounds on the cheeks and lips of human beings with its beak. The nymphs of this bug are masked with lint and dust which adhere to the body by reason of a sticky substance secreted by the insect. These nymphs frequent houses and often destroy bedbugs when the latter can be found. The adult (Fig. 166) is very dark brown and about ¾ of an inch in length.

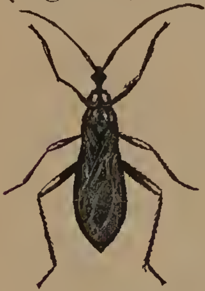

Fig. 166. — *Reduvius personatus.*

The big bedbug, *Triătoma sanguisūga*, which occurs in the southern states is nearly an inch long. It attacks man as well as chickens and sucks the blood.

The wheel-bug, *Arilus cristātus*, is of interest because of the cogwheel-like crest on its prothorax. See page 108.

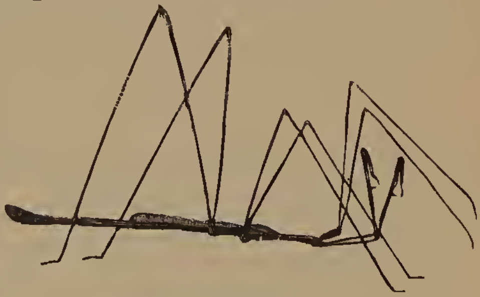

Fig. 167. — *Emesa brevipennis.*

The thread-legged bug, *Ĕmesa brevipĕnnis*, is a curious form with its long, slender body and thread-like legs (Fig. 167).

Family PHYMATIDÆ

The Ambush-bugs

The ambush-bugs are notable for the form of the front legs which are modified into grasping organs. The antennæ are also notable because the terminal segment of each is more or less enlarged into a knob-like form.

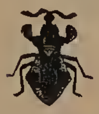
FIG. 168.— *Phymata erosa.*

The most common member of this family is *Phy̆mata erosa* (Fig. 168). It is a greenish insect, with a black band across the broadly expanded abdomen. It conceals itself in flowers, and captures the insects which come to sip nectar. It is especially abundant among the flowers of golden-rod. It overpowers and captures insects like cabbage butterflies, honey-bees and large wasps.

Family TINGIDÆ

The Lace-bugs

The Tingidæ are doubtless the most easily recognized of all Hemiptera. The lace-like structure of the hemelytra, usually accompanied by expansions of the prothorax of a similar structure, gives these insects a characteristic appearance which needs only to be once seen to be recognized in the future (Fig. 169 and 170). They are generally very small insects. But they occur in great numbers on the leaves of trees and shrubs, which they puncture in order to suck their nourishment from them. Their eggs are fastened to leaves, and covered by a brown, sticky substance; they appear more like fungi than like the eggs of other insects.

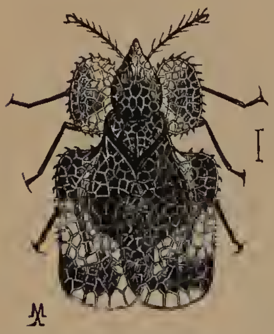
FIG. 169. — A tingid, *Corythucha arcuata.*

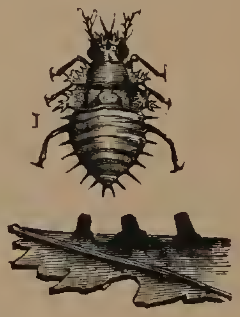
FIG. 170. — Eggs and nymph of the tingid, *C. arcuata.*

Family PYRRHOCORIDÆ

The Cotton-stainer Family

The members of this family are rather stout and heavily formed bugs, and are generally black or brown, marked with red. In this family there are two or three large cells at the base of the membrane, and from these arise branching veins (Fig. 171).

The most important member of this family is the cotton-stainer, *Dysdĕrcus suturĕllus*, which is about $\frac{3}{5}$ of an inch long (Fig. 172). The head, front part of thorax, and underside of the abdomen are red while the dark brown hemelytra are marked with light yellow lines. The nymphs are red. The insect punctures the immature bolls and the seeds within. The seeds exude a material which stains the lint an indelible yellowish color. The colonies of red nymphs may be brushed off into pans of kerosene or the bugs may be trapped in the fall under and on heaps of cotton seeds placed here and there in the field and then destroyed.

The bordered plant-bug, *Euryophthalmus succinctus*, is probably the most widely distributed species of this family. It is found from New Jersey to Mexico. It is brownish-black with the sides of the prothorax margined with orange or red. It has, under certain conditions, become injurious to cotton.

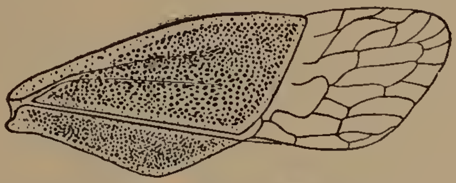

FIG. 171. — Hemelytron of *Euryophthalmus succinctus*.

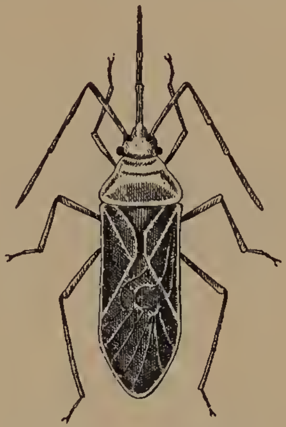

FIG. 172. — *Dysdercus suturellus*.

Family LYGÆIDÆ

The Chinch-bug Family

This, too, is a large family, about two hundred species being known to occur in the United States. Here the membrane of the wing-covers is furnished with four or five simple veins, which arise from the base of the membrane; sometimes the two inner veins are joined to a cell near the base (Fig. 173).

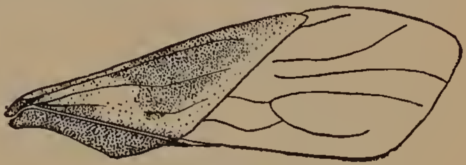

FIG. 173. — Hemelytron of *Lygæus*.

This family contains the chinch-bug, *Blissus leucopterus*, the most destructive member of the family occurring in the United States. Although quite widely distributed, its injuries have attracted most attention in the Mississippi Valley, where it has destroyed many million dollars' worth of grain. It is a small bug, measuring less than one-sixth of an inch in length. It is blackish in color, with snowy-white wing-covers, each marked with a dark spot and Y-shaped line, as shown in the Figure 174. The species is dimorphic, there being a short-winged form.

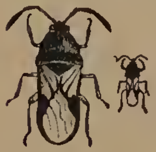

FIG. 174. — *Blissus leucopterus*.

There are two generations of the chinch-bug each year; they winter as full-grown insects and hide in stools of grasses. In the early spring they come forth and lay their eggs in fields of grain upon the roots or stems beneath the ground. The eggs hatch in about two weeks. The nymphs are red, and feed at first upon roots; afterwards they attack the stalks of the plants they infest. In about 45 days they get their growth. About this time the whole brood starts out to find new pastures, and they all march on foot in one direction, like an army. Although they are tiny insects they number millions, and so attract much attention. As soon as they find a new field of grain they lay their eggs for another brood.

Family Coreidæ

The Squash-bug Family

This family is also a very extensive one, including many species of various forms. They may be distinguished by the venation of the membrane of the hemelytra. This part is furnished with many veins, most of which spring from a cross-vein near its base (Fig. 175).

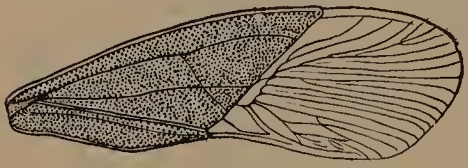

Fig. 175. — Hemelytron of *Leptocoris trivittatus*.

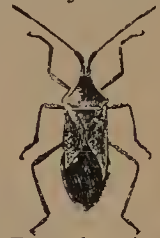

Fig. 176. — *Anasa tristis.*

The squash-bug, *Ănasa trĭstis*, is a good example of this great family. These when full-grown are brownish-black bugs, with some yellow spots along the edges of the abdomen (Fig. 176), and are dirty yellow on the under side. This bug winters in the adult state, and takes the first opportunity in the spring to lay its eggs on the leaves of squash and pumpkin vines. As soon as they hatch, the young bugs attack the vines and are apt to destroy them entirely.

Family Pentatomidæ

The Stink-bug Family

This is a family the taste and odor of which most of us know to our sorrow. We learn the flavor in one experience, and conclude that once is enough for a lifetime.

It should not be concluded, however, that only members of this family possess this disagreeable odor; for most of the Hemiptera protect themselves by rendering their bodies unpalatable in this way.

This nauseous odor is caused by a fluid which is excreted through two openings, one on each side of the under side of the body near the middle coxæ.

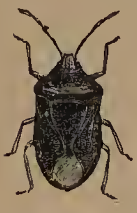

Fig. 177. — A pentatomid.

In this family the antennæ are five-jointed; the scutellum, although large, is usually less than half as long as the abdomen (Fig. 177).

Some species of this family feed upon other insects, and so are very helpful to the farmer, one species especially (*Perillus bioculatus*) being a gallant fighter against the potato-beetle. Other species feed entirely upon vegetables, while others live upon both vegetable and animal matter.

The harlequin cabbage-bug or calico-back, *Murgăntia histriŏnica*, is very destructive to cabbages, radishes, and turnips in the southern states and on the Pacific coast. It is black with bands, stripes, and margins of red or orange or yellow. The full-grown bugs live through the winter, and in the early spring each female lays on the under surface of the young leaves about twelve eggs in two parallel rows. The young bugs are pale green, with black spots. They mature in a few days, so there are many generations in one season.

Other Families of the Hemiptera

For a more detailed discussion of the following families the student is referred to "An Introduction to Entomology" by J. H. Comstock.

Family *Naucoridæ.* The creeping water-bugs are flat-bodied moderate-sized insects living in water. The front legs are fitted for grasping and the insects live among reedy or grassy, quiet waters where they creep about among the plants. There are only two genera in our fauna, *Pelŏcoris* and *Ambrȳsus*, with but a few species.

Family *Ochteridæ.* These are shore-inhabiting bugs with only a few species in the United States, all of the genus *Ochtērus.*

Family *Mesoveliidæ.* There are only two species of this family known in our fauna. Both are small insects less than one-fourth of an inch in length. One, at least, lives on the surface of the water in quiet ponds.

Family *Hebridæ.* This is a family of small plump-bodied bugs measuring less than one-eighth of an inch in length. There are two genera, *Hebrus* and *Merragāta*, containing but six species in our fauna at the present time.

Family *Hydrometridæ.* At least three species of these long, narrow-bodied insects with long, slender legs and antennæ occur in the United States (Fig. 178). They creep slowly upon the surface of the water in quiet weedy places.

Family *Schizopteridæ.* But a single species of this family has yet been found in the United States. This one is only about $\frac{1}{20}$ of an inch in length. It lives among fallen leaves, rubbish, and earth.

Family *Dipsocoridæ.* There are only two or three species of this family and they are all small, less than $\frac{1}{12}$ of an inch in length.

Family *Isometopidæ.* Two species of this family have been found in the Southwest and two in the East. Both of the eastern forms are rare and all of them are small measuring not more than $\frac{1}{10}$ of an inch in length.

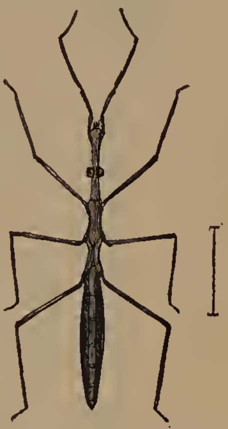

Fig. 178. — *Hydrometra.*

Family *Termatophylidæ.* This family, although small in number, is world wide in distribution. One species has been found in the United States, but only the female of this one has been described.

Family *Polyctenidæ.* The many-combed bugs are rare but are of interest because they are parasitic on bats. One species, *Hesperŏctenes lŏngiceps*, has been described from a bat in southern California. The hemelytra are vestigial.

Family *Enicocephalidæ.* These are called the unique-headed bugs because the head differs in form from all other Hemiptera. Apparently but two species have been found up to this time in the United States.

Family *Neididæ.* The Neididæ, known as stilt-bugs, are striking in appearance because the body is long and narrow and is furnished with long slender antennæ and legs (Fig. 179).

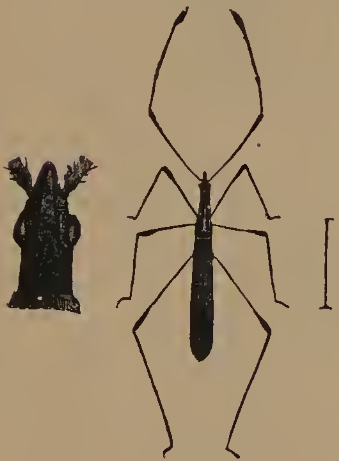

Fig. 179. — *Jalysus spinosus.*

Of the few species in our country but two are widely distributed. These are sluggish insects found in the undergrowth of woods and in meadows and pastures. The most common representative is *Jălysus spinōsus* which is widely distributed in the United States and Canada. It has been found to be a serious pest of tomatoes in some localities for it punctures the stems and fruit and sucks out the juices.

Family *Aradidæ.* The members of this family are known as the flat-bugs because their bodies are very flat and thin. They live in the cracks or beneath the bark of dead trees and logs. They are usually brownish to black and the hemelytra are reduced in size. Some of them somewhat resemble bedbugs and because of this there was an old idea prevalent in the days of log houses that bedbugs got into the house from the logs used in constructing it. There are several genera in this family and at least fifty-nine species are known in this country.

Family *Cydnidæ.* This family includes two fairly well defined groups of bugs, the burrower-bugs and the negro-bugs. Of the first group the species are generally black or very dark brown and they burrow in sandy places or beneath sticks or stones or at the roots of grasses.

The negro-bugs are short, broad, and very convex. They are mostly black and beetle-like in appearance. They infest various plants. There are only a few species.

Family *Scutellaridæ.* These are known as the shield-backed bugs because the scutellum covers nearly the whole of the abdomen. The body is short, broad, and convex (Fig. 180).

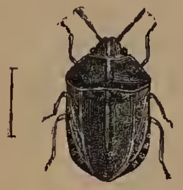

Fig. 180. — A shield-backed bug.

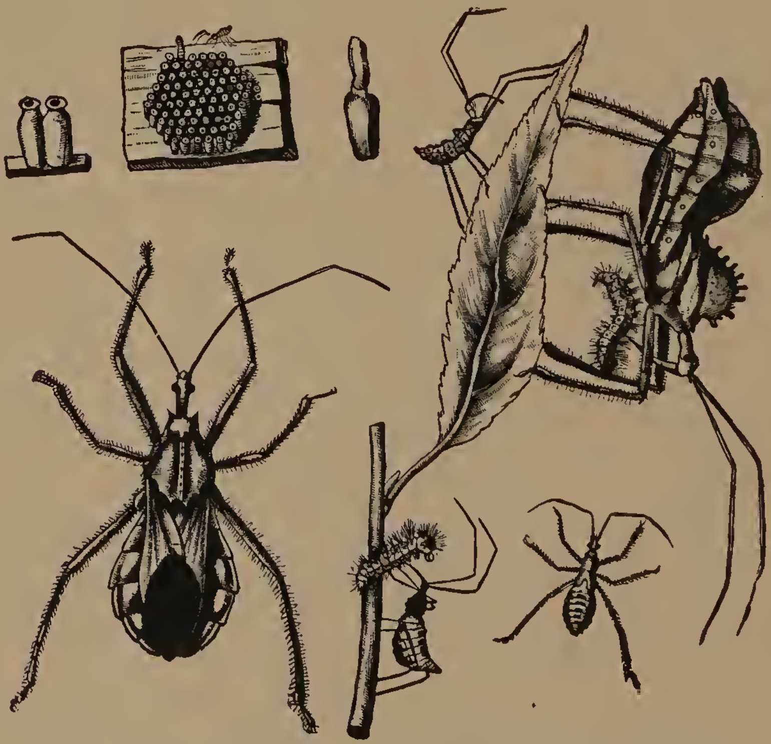

Fig. 180a. — The wheel-bug, *Arilus cristatus* (From Glover). See page 103.

CHAPTER XVIII

ORDER HOMOPTERA *

Cicadas, Leafhoppers, Aphids, Scale-bugs, and others

The winged members of this order have four wings, except in the family Coccidæ; the wings are of the same thickness throughout, and usually are held sloping at the sides of the body when at rest. The mouth-parts are formed for piercing and sucking; the beak arises from the hind part of the lower side of the head. The metamorphosis is incomplete except in some highly specialized forms.

Although the Homoptera is a well-defined order, the families of which it is composed differ greatly in the appearance of their members. For this reason there is no popular name that is applied to the order as a whole.

The wings of the Homoptera are usually membranous, but in some the front wings are subcoriaceous. In these cases, however, they are of quite uniform texture throughout, and not thickened at the base as in the Hemiptera.

Many wingless forms exist in this order; in the family Coccidæ the females are always wingless; and in the family Aphididæ the males may be either winged or wingless, while usually the sexually perfect females and certain generations of the agamic females are wingless. In the Coccidæ the males have only a single pair of wings, the hind wings being represented by a pair of club-like halteres.

In the Homoptera the front part of the head is bent under and back so that the beak arises from the hind part of the lower side of the head.

The mouth-parts are formed for piercing and sucking. The piercing organs consist of four long, bristle-like setæ, the mandibular and maxillary setæ; these are enclosed in a long, jointed sheath, which is the labium. The labium and the enclosed setæ constitute what is commonly termed the beak.

As an example of the homopterous type of head and mouth-parts those of a cicada are probably the most available, on account of the large size of these insects and the comparative ease with which the parts of the head can be distinguished. Figure 181 represents a front view of the head.

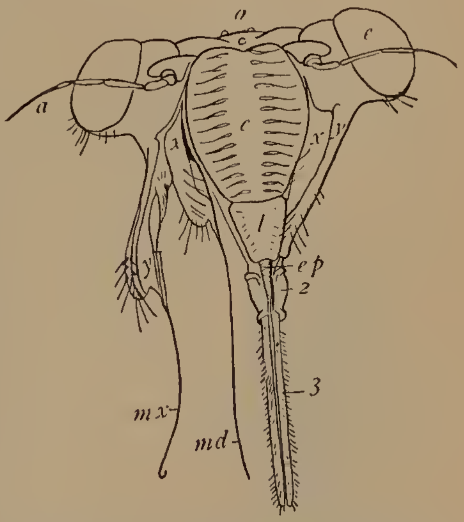

Fig. 181. — Head of a cicada, front view: *md*, mandibular seta; *mx*, maxillary seta; other letters as in Fig. 462. (After Marlatt, with changes in the lettering.)

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* Homŏptera: *homos* (ὁμός), same, *pteron* (πτερόν), a wing.

TABLE FOR DETERMINING THE FAMILIES OF THE HOMOPTERA

A. Beak evidently arising from the head; tarsi three-jointed; antennæ minute, bristle-like.
  B. With three ocelli, and the males with musical organs. Usually large insects, with all the wings entirely membranous. p. 110 . . . . Cicadidæ
  BB. Ocelli only two in number or wanting; males without musical organs.
    C. Antennæ inserted on the sides of the cheeks beneath the eyes. p. 113 . . . . Fulgoridæ
    CC. Antennæ inserted in front of and between the eyes.
      D. Prothorax not prolonged above the abdomen.
        E. Hind tibiæ armed with one or two stout teeth, and the tip crowned with short, stout spines. p. 111 . . . . Cercopidæ
        EE. Hind tibiæ having a row of spines below. p. 112 . . . . Cicadellidæ
      DD. Prothorax prolonged into a horn or point above the abdomen. p. 112 . . . . Membracidæ
AA. Beak apparently arising from between the front legs, or absent; tarsi one- or two-jointed; antennæ usually prominent and threadlike, sometimes wanting.
  B. Tarsi usually two-jointed; wings when present four in number.
    C. Wings transparent.
      D. Hind legs fitted for leaping; antennæ nine- or ten-jointed. p. 114 . . . . Chermidæ
      DD. Legs long and slender, not fitted for leaping; antennæ three- to seven-jointed. p. 114 and 118 . . . . Aphididæ and Phylloxeridæ
    CC. Wings opaque, whitish; wings and body covered with a whitish powder. p. 118 . . . . Aleyrodidæ
  BB. Tarsi usually one-jointed; adult male without any beak, and with only two wings; female wingless, with the body either scale-like or gall-like in form, or grub-like and clothed with wax. The waxy covering may be in the form of powder, of large tufts or plates, of a continuous layer, or of a thin scale beneath which the insect lives. p. 119 . . . . Coccidæ

Family Cicadidæ

The Cicadas

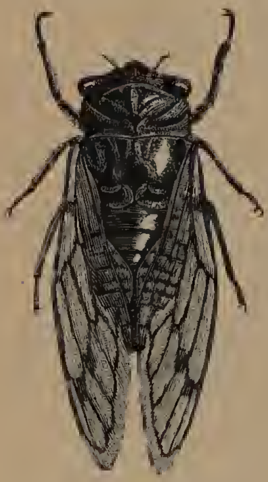

Fig. 182. — *Tibicen linnei.*

The large size and well-known songs of the more common species of this family render them familiar objects. It is only necessary to refer to the periodical cicada and to the harvest-flies, one of which is represented by Figure 182, to give an idea of the more striking characteristics of this family.

The species are generally of large size, with a subconical body. The head is wide and blunt, with prominent eyes on the outer angles, and three bead-like ocelli arranged in a triangle between the eyes. They are notable for the complex musical organs of of the males with which they produce their so-called song, a loud, sustained, usually high-pitched noise emitted during the warm days of summer. There are over seventy species of cicadas in our fauna.

They are several species of cicadas that are commonly known as dog-day cicadas or harvest-flies; a common one of these is the species that has received the popular name of the *lyreman;* this is *Tibīcen linnēi* (Fig. 182). The shrill cry of this species, which is the most prominent of the various insect sounds heard during the latter part of the summer, has made its author familiar to many. This insect varies both in size and colors. It commonly measures two inches to the tip of the closed wings; it is black and green, and more or less powdered with white beneath.

The member of this family that has attracted most attention is the periodical cicada, *Magicicada septĕndecim*. This species is commonly known as the seventeen-year locust; but the term *locust* when applied to this insect is a misnomer, the true locusts being members of the order Orthoptera. This species is remarkable for the long time required for it to attain its maturity. The eggs are laid in the twigs of various trees by the female. Sometimes this cicada occurs in such great numbers that they seriously injure small fruit trees, by ovipositing in the twigs and smaller branches. The nymphs hatch in about six weeks. They soon voluntarily drop to the ground, where they bury themselves. Here they obtain nourishment by sucking the juices from the roots of forest and fruit trees. And here they remain till the spring of the seventeenth year following. They emerge from the ground during the last half of May, at which time the empty pupa-skins may be found in great numbers, clinging to the bark of trees and other objects. It is at this period that the cicadas attract attention by the shrill cries of the males. The insects soon pair, the females oviposit, and all disappear in a few weeks.

Seventeen distinct broods of this species have been traced out; so that one or more broods appear somewhere in the United States nearly every year. In many localities, several broods co-exist, each brood appearing in distinct years. There is a race of the species in which the period of development is only thirteen years. This variety is chiefly a southern form, while the seventeen-year broods occur in the more northern states.

Family CERCOPIDÆ

The Spittle-insects or Frog-hoppers

During the summer months one often finds upon various shrubs, grass, and other herbs, masses of white froth. In the midst of each of these masses there lives a young insect, a member of this family. In some cases as many as four or five insects inhabit the same mass of froth. It is asserted that these insects undergo all their transformations within this mass; that when one is about to molt for the last time, a clear space is formed about its body and the superficial part of the froth dries, so as to form a vaulted roof to a closed chamber within which the last molt is made.

The adult insects wander about on herbage, shrubs, and trees. They have the power of leaping. The name frog-hoppers has doubtless grown out of the fact that formerly the froth was called "frog-spittle" and was supposed to have been voided by tree-frogs from their mouths. The name is not, however, inappropriate, for the broad and depressed form of our more common species is somewhat like that of a frog.

Most of the froth of spittle insects is voided from the anus but a mucilaginous material excreted by large hypodermal glands on the seventh and eighth abdominal segments is added to the mass which renders it viscous and helps to retain the air bubbles introduced into it by the insect. The froth is evidently a means of protection.

In this family the antennæ are inserted in front of and between the eyes; the prothorax is not prolonged over the abdomen, as in the Membracidæ; the tibiæ are armed with one or two stout teeth, and the tip is crowned with short, stout spines, as shown in Figure 183.

One of the more common and very widely distributed species is *Lepyrōnia quadrangulāris* (Fig. 183). The adult of this species is a brownish insect, densely covered with microscopic hairs, and black beneath; the hemelytra are marked with two oblique brown bands.

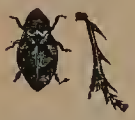

Fig. 183. — *Lepyronia quadrangularis.*

Family Membracidæ

The Tree-hoppers

In the tree-hoppers, the prothorax extends backward like a roof over the body, often quite covering it. In some cases the prothorax is elevated above the head, so that it looks like a horn (Fig. 184); in others it is shaped like a tam-o'-shanter; and sometimes it has horns, one on each side, which have given one species the name of the buffalo tree-hopper.

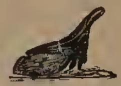

Fig. 184. — *Enchenopa binotata.*

Many species of this family live upon bushes or small trees, and all are good leapers; hence the common name, tree-hoppers. Some species excrete honey-dew, and are attended by ants. All feed upon plants, but they seldom appear in sufficient numbers to do much damage. Sometimes the females of the buffalo tree-hopper, *Cerēsa būbalus*, injure apple trees by laying their eggs in large numbers in the bark of the smaller branches (Fig. 185).

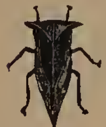

Fig. 185. — *Ceresa bubalus.*

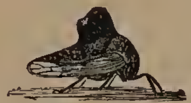

Fig. 186. — *Telamona.*

The tree-hoppers of the genus, *Telamōna*, have a hump-backed appearance (Fig. 186). In many of the tree-hoppers, the eyes have a keen, droll look, and the line that separates the head from the prothorax gives them the appearance of wearing glasses (Fig. 187).

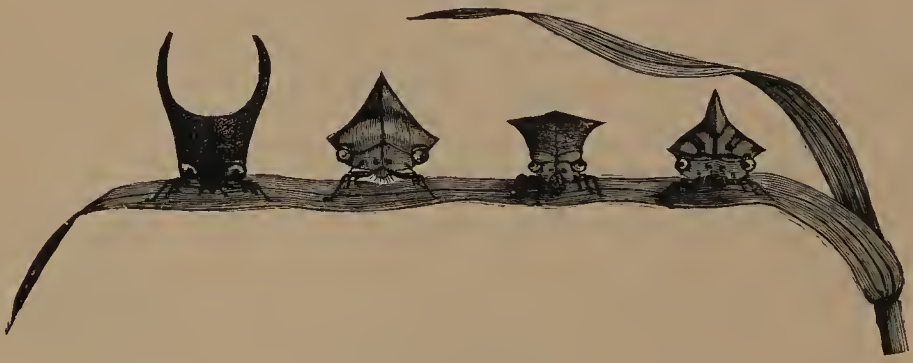

Fig. 187. — Tree-hoppers.

Family Cicadellidæ

The Leafhoppers

The most abundant members of the Homoptera, except perhaps the aphids, are the leafhoppers. Large numbers of them can be easily collected by sweeping grass, herbage, or the foliage of shrubs.

The leafhoppers are slender, small insects, distinguished by the form of the hind tibiæ, which are nearly or quite as long as the abdomen, curved, and armed with a row of spines on each margin (Fig. 188).

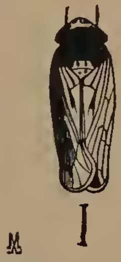

Fig. 189 — *Euscelis exitiosus.*

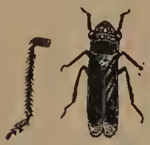

Fig. 188. — *Oncometopia undata.*

Among the leafhoppers that have attracted attention on account of their injuries to vegetation are the following: the destructive leafhopper, *Eūscelis exitiōsus*, which is represented greatly enlarged by Figure 189, sometimes infests grains to a serious extent. The grape-vine leafhopper, *Erythroneura comes*, is a well-known pest that infests the leaves of the grape. It is about one-eighth inch in length with varied markings of yellow and red on its back. Eleven varieties of this one species have been described. The rose leafhopper, *Empoa rosæ*, is also a well-known pest, as it often swarms on the leaves of roses, doing great damage. Its presence is usually indicated by numerous white cast skins adhering to the lower side of the leaves. The potato leafhopper, *Empoăsca fābæ*, is one of the chief pests of the potato. In addition to injuring the plants, it disseminates a disease of the foliage known as "hopperburn." The adults are about $\frac{1}{8}$ of an inch long and of a pale yellowish-green color.

Family FULGORIDÆ

The Lantern-fly Family

This family is remarkable for certain exotic forms which it contains. Chief among these is the great lantern-fly of Brazil. Scarcely less strange are the candle-flies of China and the East Indies. The popular names of these insects refer to the fact that they were thought to be phosphorescent, but we know of no native species that possesses this peculiarity. There does not seem to be any typical form of the body characteristic of this family. The different genera differ so greatly, that on superficial examination they appear to have very little in common. Some even resemble butterflies and moths, while others might easily be mistaken for neuropterous genera.

The most useful character for recognizing these insects is the form and position of the antennæ. These have two large basal segments and a bristle-like terminal portion. They are situated on the side of the cheek beneath the eyes. Although the Fulgoridæ are vegetable feeders, none of our species has attracted the attention of agriculturists. There are, however, certain exotic species which do great injury to crops.

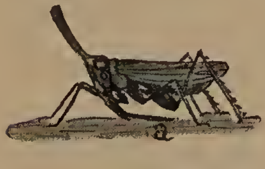

Fig. 190. — *Scolops.*

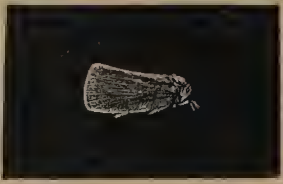

Fig. 191. — *Ormenis septentrionalis.*

The two accompanying figures will serve to show the wonderful variations in form of these insects; many other types exist. Figure 190 represents a common species of *Scolops*, which occurs in grassy places. In this genus the head is greatly prolonged, as with the exotic candle-flies. Figure 191 represents *Ormenis septentrionālis*, a beautiful pale-green species powdered with white, which feeds on wild grape-vines, drawing nourishment from the tender shoots and midribs of the leaves during its young stages.

Family CHERMIDÆ

The Jumping Plant-lice

The jumping plant-lice are comparatively small insects; our more common species measuring only from one-twelfth to one-sixth inch in length, and it is rare that we find any twice that size. When examined with a lens they appear like tiny cicadas (Fig. 192). Their hind legs are formed for jumping; their antennæ are ten-jointed or rarely nine- or eleven-jointed. They are very active creatures, jumping and taking flight when disturbed.

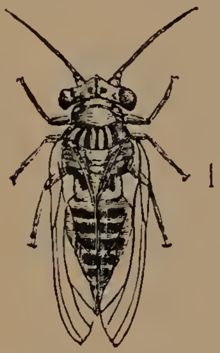

FIG. 192.—The pear-tree Psyllia, greatly enlarged.

The Chermidæ subsist entirely upon the juices of plants, and some of them cause serious injuries. Many species form galls; one of the larger of these infests the leaves of hackberry.

The most destructive member of this family in the United States is the pear-tree psyllia, *Psȳllia pyrĭcola.* This is a minute species, measuring only one-twelfth inch in length to the tip of the folded wings (Fig. 192).

The eggs are laid early in the spring in the creases of the bark and in the leaf-scars of the smaller branches. The young nymphs migrate to the axils of the leaf petioles and the stems of the forming fruit; later they spread to the under side of the leaves. They secrete large quantities of honey-dew, upon which a blackish fungus grows. There are at least four generations each year. Badly infested trees shed their leaves and young fruit in midsummer. In some cases orchards have been so badly injured by this pest that they have been cut down by their owners.

Family APHIDIDÆ

The Plant-lice or Aphids

The plant-lice or aphids are well-known insects; they infest nearly all kinds of vegetation in all parts of the country. Our most common examples are minute, soft-bodied, green insects, with long legs and antennæ, which appear on various plants in the house and in the field. Usually, at least, in each species there are both winged and wingless forms (Fig. 193). There are many species of aphids, nearly all of which are of small size; some measure less than $\frac{1}{25}$ of an inch in length; and our largest species, only $\frac{1}{5}$ or $\frac{1}{4}$ of an inch.

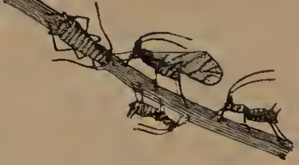

FIG. 193. — A group of aphids.

The body is usually more or less pear-shaped. The winged forms have two pairs of delicate, transparent wings. These are furnished with a few simple or branched veins. The first pair of wings is larger than the other, and the two wings of each side are usually connected by a compound hooklet or several hamuli. The beak is three-jointed, and varies greatly in length; sometimes it is longer than the body. The compound eyes are prominent, and ocelli are also usually present. The antennæ are from three- to seven-jointed. On the back of the sixth abdominal segment there is, in many species, a pair of tubes, the cornicles, through which a wax-like material is excreted. In some genera these organs are merely perforated tubercles, while in still other genera they are wanting.

Many species of aphids excrete a sweet substance known as honey-dew from the posterior end of the alimentary canal. It is sometimes produced in such quantities that it forms a glistening coating on the leaves of the branches below the plant-lice, and stone walks beneath shade-trees are often densely spotted with it. This honey-dew is fed upon by bees, wasps, and ants. The bees and wasps take the food where they find it, paying little if any attention to its source; but the ants recognize in the plant-lice useful auxiliaries, and often care for them as men care for their herds. This curious relationship will be discussed further in the chapter on ants.

In addition to honey-dew, many aphids excrete a white waxy substance. This may be in the form of powder, scattered over the surface of the body, or it may be in large flocculent or downy masses; every gradation between these forms exists.

The plant-lice are remarkable for their peculiar mode of development. The various species differ greatly in the details of their transformation, but the following generalizations illustrated by the life history of the cabbage aphid, *Brevicoryne brassicæ*, may be made.

The stem-mother. — In the spring there hatches from each surviving egg which was laid on a cabbage stump in the fall, a female aphid known as the stem-mother because she gives rise to all of the succeeding generations during the summer. She brings forth her young alive and is therefore viviparous. She also bears young aphids without having mated (there are no male aphids in the spring) and is therefore parthenogenetic.

The wingless agamic form. — This stem-mother gives birth to young which do not develop wings and which are all females. These reproduce parthenogenetically and are known as *the wingless agamic forms*. These reproduce their kind for a variable number of generations and then produce the next form.

The winged agamic form. — After a variable number of generations of the wingless agamic form have been developed and the food-plant has become overstocked by them, there appears a generation which is winged. These are all parthenogenetic, viviparous females. They are known as *the winged agamic forms*. These migrate to other cabbage plants which are not overstocked with the wingless plant-lice.

When the migrating winged agamic form becomes established on fresh plants, it produces young which are all females of the wingless agamic form. After a variable number of generations of the winged and wingless forms have been developed and fall approaches, the egg-laying (oviparous) females and the males are produced.

The males and oviparous females. — These are the true sexual forms. They pair and each female lays one or more eggs on the cabbage stump which rest over the winter. In the case of the cabbage aphid the oviparous female is wingless and the male is winged. Other aphids differ in this respect. In some species the females are winged and in a few the males are wingless.

Primary and secondary host plants. — Some aphids deposit their eggs in the fall on a certain plant which is called the primary host plant; but in the spring when the stem-mothers have appeared and have given rise to winged forms in the second and third generations these winged aphids become migrants and fly to another perhaps totally unrelated plant, which is called the secondary host plant. On this plant the aphids live during the summer but return to the primary host plants in the fall on which the sexes are produced and the eggs are laid.

The potato aphid, *Illinŏia solanifōlii*, deposits its eggs in the fall on the rose, its primary host plant; but in the spring the winged migrants leave the rose and go to the potato to pass the summer. Toward fall winged forms appear and return to the rose where the sexual forms are produced and the eggs are laid.

The rosy apple aphid, *Anurāphis rōseus*, is another example of this habit. The eggs of this aphid are deposited on the apple in the fall but in the spring winged migrants fly to the narrow-leaved plantain and on the roots of this plant the insects pass the summer.

Some aphids are bark-feeding. For example, the giant hickory aphid, *Longistĭgma cāryæ*, is found feeding on the branches of hickory, maple, and other forest trees. It is the largest aphid known, measuring nearly $\frac{1}{2}$ of an inch to the tips of its wings (Fig. 194).

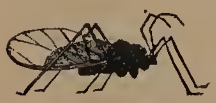

Fig. 194. — The giant hickory aphid.

Other aphids are leaf-feeding like the potato aphid already mentioned and the spring grain aphid, or "green bug," *Toxŏptera grăminum*, which is so injurious to wheat and oats in some seasons in the Mississippi Valley.

There are also root-feeding species. For instance the corn-root aphid, *Anurāphis maidiradicis*, which is such a pest on the roots of corn in the Mississippi Valley; and the strawberry-root aphid, *Aphis forbesi*, which infests the roots of strawberry plants. Both of these species are attended by ants and placed upon the roots of corn and strawberries by the ants.

Some aphids secrete great quantities of white waxy threads which cover their bodies like wool. These are known as the woolly aphids. One of these woolly aphids which occurs on the apple, is known as the woolly apple aphid, *Eriosōma lanĭgera*. It has a complex life history. Its eggs are deposited on the bark of the elm. There they hatch in the spring and the young crawl to the leaves and by their presence produce rosettes at the ends of branches. Later, winged forms go to the apple where several generations are produced, some of which live on the branches and some on the roots underground. The root form may be very injurious to the trees, especially in sandy soil. Finally in the autumn, the winged forms on the apple fly back to the elm where the sexual individuals are produced and the eggs are laid. It should be said that some of the aphids remain on the apple trees all winter.

Large numbers of a woolly aphid are often found crowded together on the under side of the branches of alder. This species is known as the alder-blight, *Procĭphilus tessellāta*. In addition to the white excretion with which the body is covered this insect excretes large quantities of honey-dew. The result is that the branches infested by this insect, and those beneath the clusters of aphids, become blackened with fungi that grow upon this secretion. There is also a curious fungus which grows in large spongy masses beneath the clusters of plant-lice; this is known as *Scorias spongiosa*. It grows in the honey-dew that falls upon it.

The beech-tree blight, *Prociphilus imbricātor*, infests both the twigs and leaves of beech. Like the preceding species it occurs in clusters of individuals, each of which is clothed with a conspicuous downy excretion. These clusters often attract attention by the curious habit that the insects have of waving their bodies up and down, the plume-like masses of excretion rendering them very conspicuous. When an infested limb is jarred the aphids emit a shower of honey-dew. Owing to the abundance of this secretion, the branches and leaves of an infested tree become blackened by growths of fungi, as with the preceding species.

Other aphids produce galls of various shapes and sizes on the leaves of plants.

The cockscomb elm-gall, *Cŏlopha ulmĭcola.* — There are two species of aphids that make similar galls on the leaves of elm. These galls are commonly known as cockscomb elm-galls on account of their shape. Those made by the two species of aphids are so similar that a description of one will apply to the other. In each case the gall is an excrescence resembling a "cock's comb" in form, which rises abruptly from the upper surface of the leaf. It is compressed, and has its sides wrinkled perpendicularly and its summit irregularly gashed and toothed. It opens on the under side of the leaf by a long slit-like orifice.

The poplar-leaf gall aphid, *Thecābius populicaulis.* — This aphid is common on several species of poplar. It makes a swelling the size of a small marble on the leaf at the junction of the petiole with the blade. This gall is of a reddish tint, and has on one side a slit-like opening.

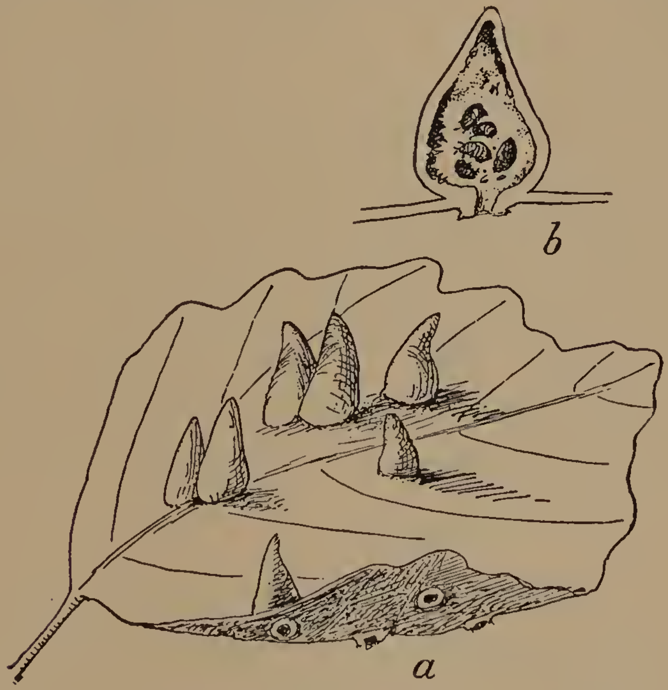

Fig. 195. — The witch-hazel cone-gall: *a*, natural size; *b*, section of gall, enlarged. (From Pergande.)

The witch-hazel cone-gall aphid, *Hŏrmaphis hamamĕlidis*, causes cone-like galls on the leaves of witch-hazel (Fig. 195).

Family PHYLLOXERIDÆ

The Adelgids and the Phylloxerids

In this family both the sexually perfect females and the parthenogenetic forms lay eggs. Moreover, the cornicles are wanting and the venation of the wings differs from that of the true aphids.

Some members of this family live on conifers and cause galls on them. One species, *Adĕlges abietis*, lives on the Norway spruce and causes pineapple-shaped galls sometimes all over the tree (Fig. 196).

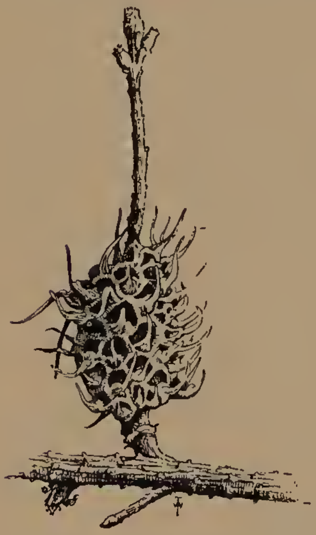

FIG. 196. — Gall of *Adelges abietis.*

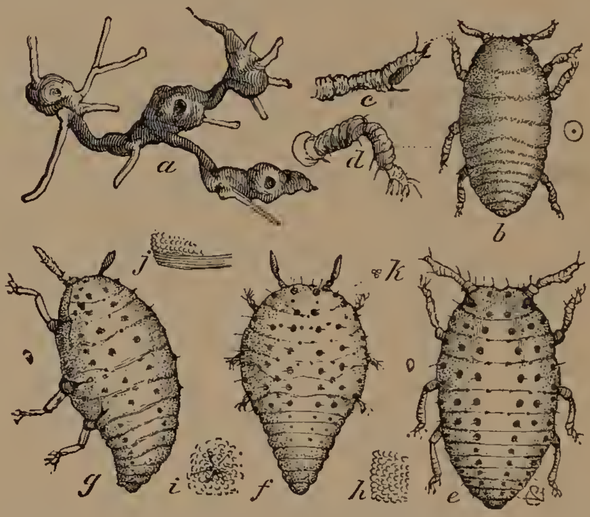

FIG. 197. — *Phylloxera*, root-inhabiting form: *a*, roots of Clinton vine showing the swellings; *b*, nymph as it appears when hibernating; *c*, *d*, antenna and leg of same; *e*, *f*, *g*, forms of more mature lice. (From Riley.)

The most notorious and serious pest of this family is the grape phylloxera, *Phyllŏxera vitifōliæ*, which is a native insect on the American wild grape. Some of these aphids live on the foliage of the vines and cause small hollow galls on the leaves. Others live underground on the roots and cause swellings or nodules to form on the roots (Fig. 197). The infested roots may decay and the vines may die. In France where the aphid has been such a serious pest on the European type of grape it is the custom to use rootstocks of the native American wild grape on which to grow the European vines. The American rootstocks are resistant to the attacks of the phylloxera.

Family ALEYRODIDÆ

The Aleyrodids or White Flies

The members of this family are small or minute insects; our more common species have a wing-expanse of about $\frac{1}{8}$ of an inch. In the adult state both sexes have four wings, differing in this respect from the Coccidæ, with which they were classed by the early entomologists. The wings are transparent, white, clouded or mottled with spots or bands. The wings, and the body as well, are covered with a whitish powder. It is this character that suggested the common name *white flies.*

In the immature stages, these insects are scale-like in form and often resemble somewhat certain species of the genus *Lecanium* of the family Coccidæ. Except during the first stadium, the larvæ remain quiescent upon the leaves of the infested plant and in most species are surrounded or covered by a waxy excretion. In Figure 198 there is represented one of the many forms of this excretion.

The members of this family feed exclusively on the leaves of the host-plants. With few exceptions they are not of economic importance; and also with few exceptions, the injurious species are not widely distributed over the world as are many aphids and coccids. They are most abundant in tropical and semi-tropical regions.

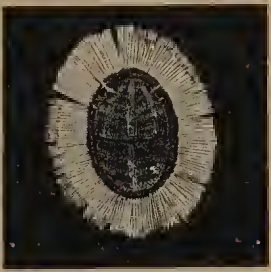
Fig. 198. — *Aleyrodes.*

The greenhouse white fly, *Asterŏchiton vaporariōrum*, is an important pest of the greenhouse. It infests very many species of plants that are grown under glass; and sometimes it is a serious pest in the open on tomato and other plants that are set out after the weather is warm.

The citrus white fly, *Dialeurōdes cĭtri*, is a well-known pest in the orange-growing sections of our country, and is also found in greenhouses in the North. It infests all citrus fruits grown in this country and is found on several other plants.

Family Coccidæ

The Scale-insects or Bark-lice, Mealybugs, and others

The family Coccidæ includes the scale-insects or bark-lice, the mealybugs, and certain other insects for which there are no popular names. To this family belong many of the most serious pests of horticulturists; scarcely any kind of fruit is free from their attacks; and certain species of scale-insects and of mealybugs are constant pests in greenhouses. Most of the species live on the leaves and stems of plants; but some species infest the roots of the host-plants. The great majority of the species remain fixed upon their host during a part of their life-cycle, and can thus be transported long distances while yet alive, on fruit or on nursery stock; this has resulted in many species becoming world-wide in distribution.

Happily some scale insects are useful to man. The lac-insect, *Tachardia lacca*, furnishes the stick-lac of commerce, from which shellac is made. Formerly, a red dye was obtained from the dried bodies of the cochineal insect, *Coccus cacti*, but recently this dye has been largely supplanted by the coal-tar dyes. China-wax is an excretion of the pe-la insect, *Ericērus pe-la*, and was formerly used in China in making candles.

In the adult state, the two sexes of coccids differ greatly in form. The males are usually winged (Fig. 199, 1*b*); in a few species they are either wingless or have vestigial wings. The fore wings are usually large, compared with the size of the body; the hind wings are always greatly reduced in size; usually they are a pair of club-shaped halteres, but in a few forms they are more or less wing-like. Each hind wing is furnished with a bristle, which is hooked at the end and fits into a pocket or fold

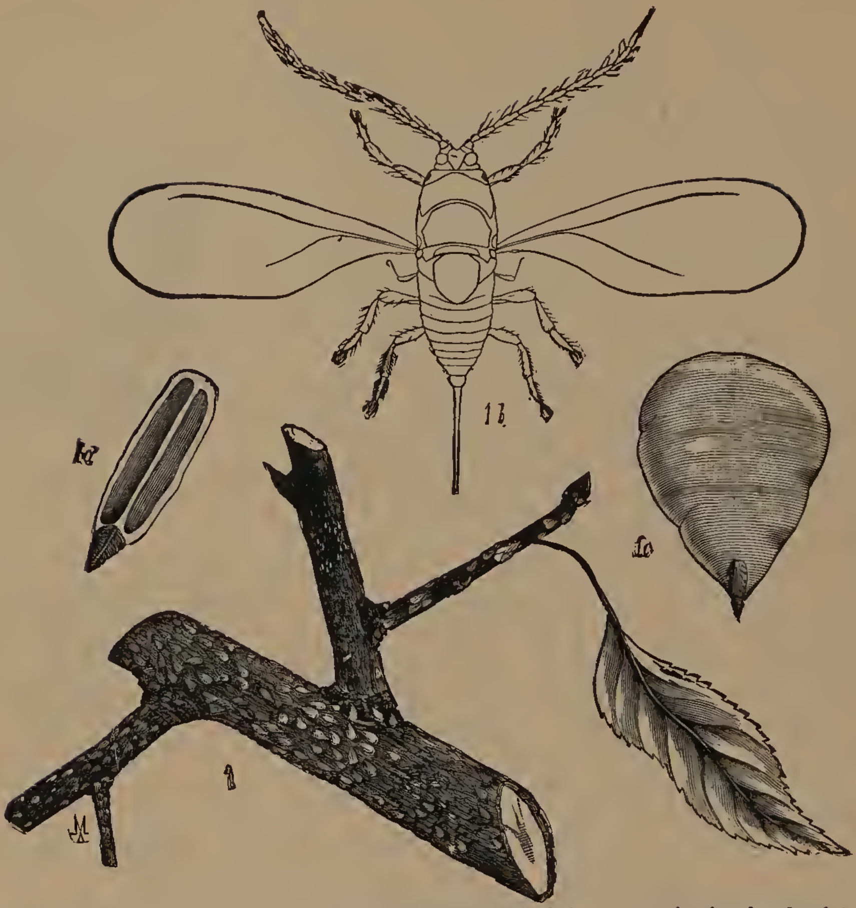

FIG. 199. — *Chionaspis furfura:* *1*, scales on pear, natural size; *1a*, scale of male, *1b*, adult male, *1c*, scale of female, enlarged.

on the inner margin of the fore wing of the same side; in a few species there are two or three or more of these hamuli.

The legs are wanting in many adult females, having been lost during the metamorphosis. In adult males they are of ordinary form; except in a few species, the tarsi are one-jointed, and each is furnished with a single claw.

The caudal end of the abdomen of the male usually bears a slender tubular process, the *stylus*.

The female coccid is always wingless, and the body is either scale-like or gall-like in form, or grub-like and clothed with wax. The waxy covering may be in the form of powder, of large tufts or plates, of a continuous layer, or of a thin scale, beneath which the insect lives. The antennæ in many species are entirely wanting in the adult females.

The mouth-parts of the adult males are lacking and they do not take food. In the case of the females of the more common species the maxillary and mandibular setæ are long and well developed for penetrating the tissues of plants.

THE MOTILE COCCIDS

We usually think of scale insects as fixed on a host-plant and unable to move about. There are, however, several subfamilies of coccids, the members of which are so generalized that the nymphs and adults possess normal, functional legs and are capable of movement over the host-plant although the amount of movement by these forms is usually not great. In fact some of the tortoise scales are practically fixed.

The division into motile and non-motile forms is a purely artificial one used for the sake of a clearer understanding of these important insects.

The cottony-cushion scale, *Icērya pŭrchasi.* — This beautiful insect (Fig. 200) was at one time the most dangerous insect pest in California, and did a great amount of injury. It is an introduced Australian species, and has been subdued to a great extent by the introduction of an Australian lady-bug, *Rodōlia cardinālis*, which preys upon it. The body of the adult female is scale-like, dark orange-red, and has the dorsal surface more or less covered with a white or yellowish-white powder. The insect secretes a large egg-sac, which is beautifully ribbed.

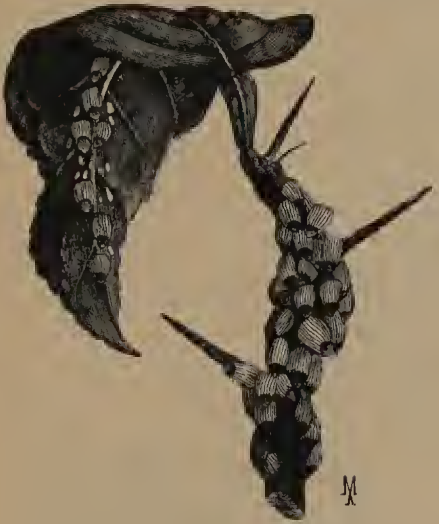

FIG. 200. — *Icerya purchasi.* Females, adult and young, on orange.

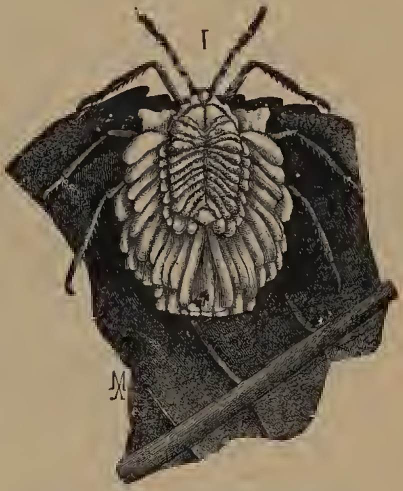

FIG. 201. — *Orthezia*, enlarged.

Orthezia. — The members of this genus occur not uncommonly on various weeds. They are remarkable for the calcareous secretion with which the body is clothed. This is in the form of long plates. Figure 201 represents a nymph; in the adult female the secretion becomes more elongated posteriorly, and forms a sac containing the eggs mixed with a fine down. Later, when the young are born, they remain in the sac till they have themselves secreted a sufficient amount of the lamellar matter to cover them.

The mealybugs. — The mealybugs are common pests in greenhouses all over this country, especially the long-tailed mealybug, *Pseudocŏccus longispīnus* (Fig. 202). In California there are several species which live in the open and become serious pests to citrus trees. Mealybugs excrete a white waxy material which may be in the form of a white powder over the body or of white threads like wool.

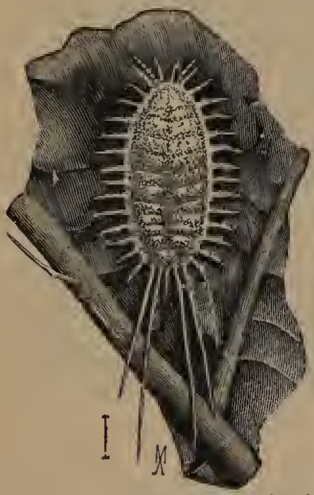

FIG. 202. — *Pseudococcus longispinus*, female, enlarged.

The tortoise or soft scales. — The tortoise scales are so-called because the bodies of the females are usually shaped like the shell of a tortoise. The body of the female is cleft at the caudal end and, in our more common forms, is unprotected by wax or other form of covering. They are, therefore, often called soft scales.

Legs are present in the first and usually in the second stage nymphs and the first stage nymphs are especially active. The adult females are usually well fixed to their host-plant.

Many of them excrete very little wax, the body being practically naked, and the eggs, or the young in the viviparous species, are deposited beneath the body; in other species, although the body is nearly naked, the adult female excretes a large, cottony egg-sac; and in still others the body is deeply encased in wax.

The soft scale, *Lecānium hespĕridum*, is the commonest and most widely spread member of this subfamily; it infests a great variety of plants; in the North, it is very common in greenhouses; in the warmer parts of the country it lives out of doors. See Figure 206b, page 124.

The members of the genus, *Pulvināria*, include species in which the body of the female resembles Lecanium but which excrete a large cottony egg-sac. The cottony maple scale, *Pulvināria vītis*, is common on the maple, osage orange, grape, and other plants (Fig. 203).

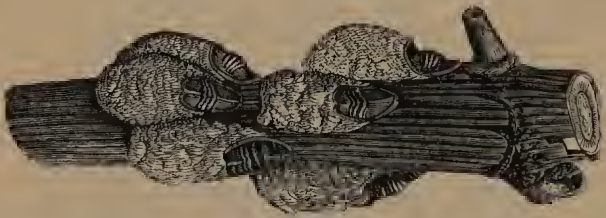

FIG. 203. — *Pulvinaria vitis.* Females, with large cottony egg-sacs, on grape, natural size

THE NON-MOTILE COCCIDS

The greater number of the common scale insects of this country, especially those which are of economic importance, are fixed to the host-plant in the adult (female) stage. The legs of the newly hatched female nymphs are lost in the first molt and the adult female becomes incapable of movement.

The armored scales. — The great majority of the common scale insects of this country differ from the forms already described in that the body of the insect, except for a very short period after birth, is covered with a scale composed in part of a waxy excretion of the insect and partly of molted skins. In the lecaniums the scale-like object is the body of the insect; but in the case of the oyster-shell bark-louse (Fig. 204), the San José scale and of many other forms, the scale-like object commonly seen is not the insect, but a waxy armor beneath which it lives.

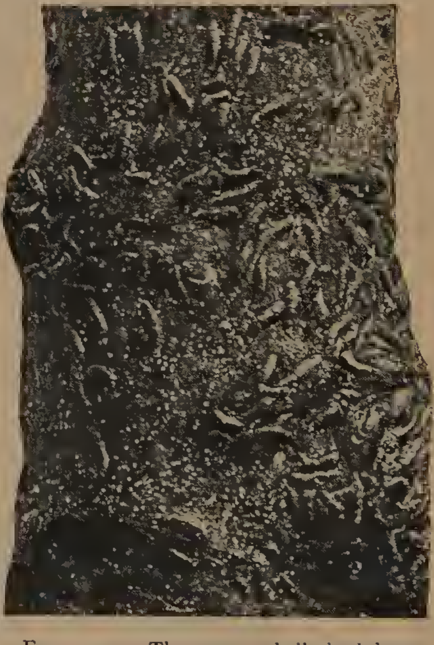

FIG. 204. — The oyster-shell bark-louse, *Lepidosaphes ulmi;* the young appear as white dots.

The young insects of this group resemble in general appearance those of other scale insects. Their active stage, however, is much shorter. After crawling about over the twigs of a tree for a few days, the young scale insect settles upon a suitable place and immediately begins to excrete fine threads of wax which soon become compacted into a thin pellicle covering the body. As the insect grows and sheds its skin, this cast skin is joined to the excretion and forms a part of the scale. This is the bright-colored, nipple-like prominence, seen in the center of the San José's scale and of the red scale of the orange; and two of them may be seen at the smaller end of the scale of the oyster-shell bark-louse. The position of the cast skins in the scale differs in different genera, and forms a good character for classification.

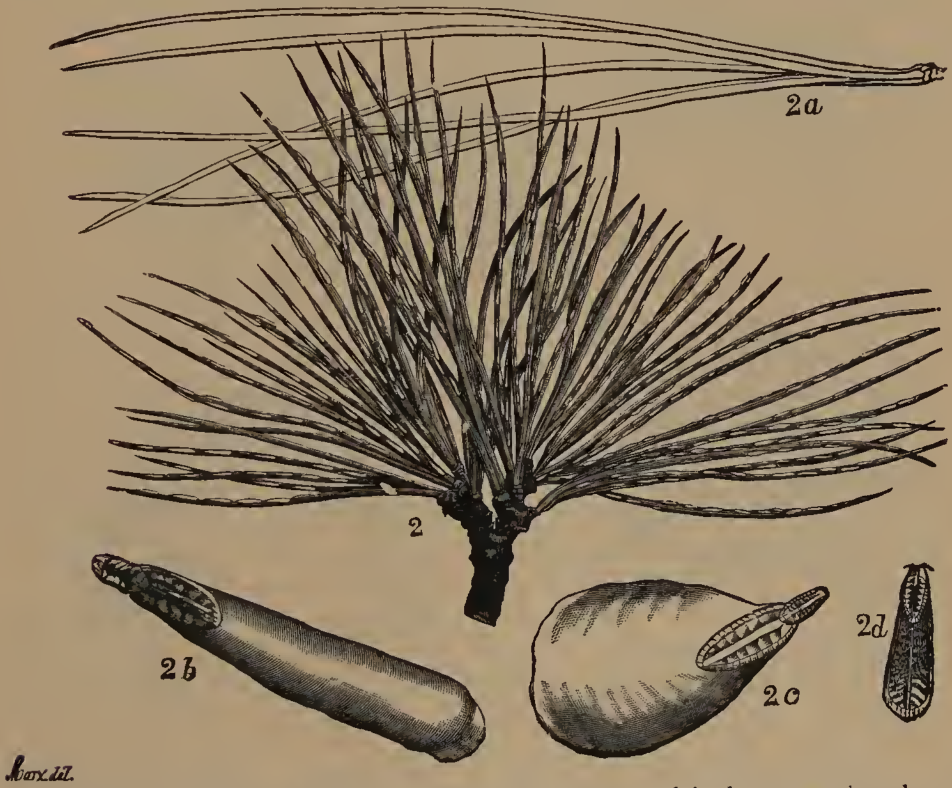

FIG. 205. — *Chionaspis pinifoliæ*: *2*, scales on *Pinus strobus*, natural size, leaves stunted; *2a*, leaves not stunted by coccids; *2b*, scale of female, usual form, enlarged; *2c*, scale of female, wide form, enlarged; *2d*, scale of male, enlarged.

Closely allied species differ but little in the form of the scale. To distinguish these it is necessary to study the insects themselves, which are found beneath the scales. The distinctions between closely allied species are such that it requires very close observation and much skill in this particular line to make the determinations, a careful preparation of the specimens and an excellent microscope being necessary requisites.

The different species of scale-insects vary as regards their food habits. We find that certain species infest particular plants and will feed upon no others; thus, the red-scale of the orange does not trouble deciduous fruits. On the other hand, other species have a wide range of food plants. This is true of the San José scale, which infests a great variety of both cultivated and wild plants.

Figure 205, represents the well-known pine-leaf scale, *Chionăspis* *pinifōliæ*, which occurs on various species of pine wherever these trees grow in the United States; Figure 199 represents the scurfy scale *Chionaspis furfura*, which is very destructive to apples and pears; while the San José scale, *Aspidiōtus perniciōsus*, which is one of the most serious pests of various fruit trees in this country, is shown in Figure 206.

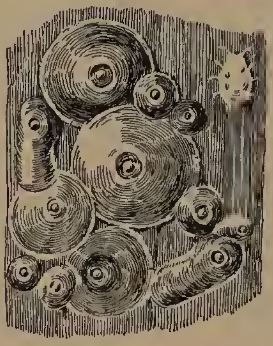

Fig. 206. — San José scale, much enlarged.

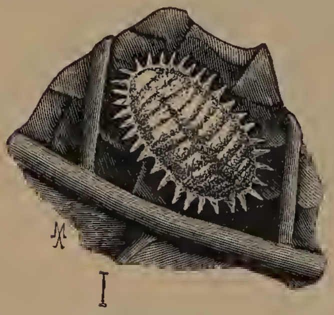

Fig. 206a, — *Pseudococcus citri*, a mealybug that is a pest in greenhouses and of orange trees in warm regions.

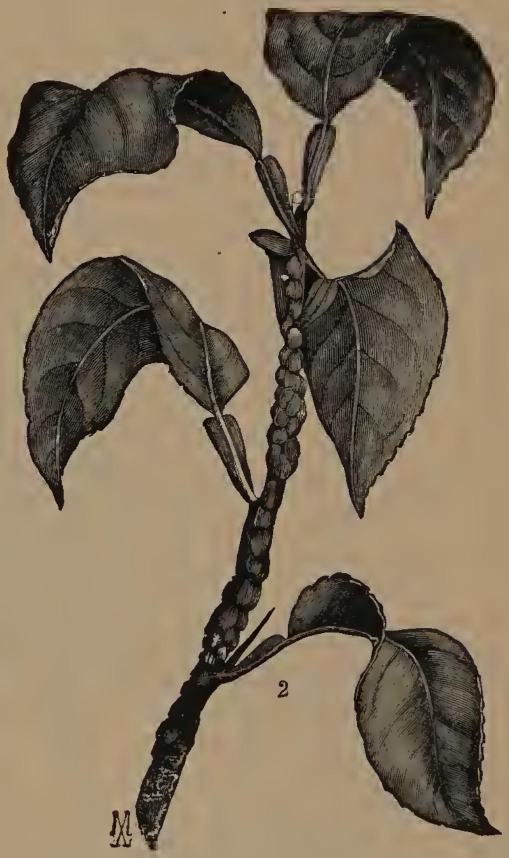

Fig. 206b, — *Lecanium hesperidum*, adult females, natural size.

CHAPTER XIX

ORDER DERMAPTERA *

The Earwigs

The winged members of this order usually have four wings; but in some of them the hind wings are vestigial or wanting; the fore wings are leathery, very small, without veins, and when at rest meet in a straight line on the back; the hind wings, when well developed, are large, with radiating veins, and when at rest are folded both lengthwise and crosswise. The mouth-parts are formed for chewing. The caudal end of the body is furnished with a pair of appendages, the cerci, which resemble forceps. The metamorphosis is incomplete.

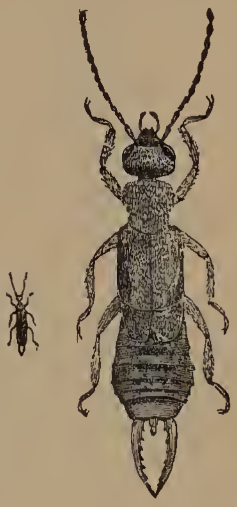

FIG. 207. — An earwig, *Labia minor.*

These are long, narrow-bodied insects with short, thickened fore wings which, when at rest, meet in a straight line on the back (Fig. 207). They can be distinguished from beetles by the pair of forceps-like appendages, the cerci, at the caudal end of the body.

The common name, earwig, was given these insects in England, and has reference to a widely spread fancy that these insects creep into the ears of sleeping persons. The earwigs are more common in this country in the South and on the Pacific Coast. They are nocturnal in habits and feed on flowers, fruits and vegetables and some species feed on animal matter, especially dead insects.

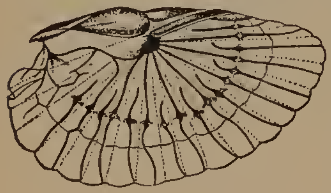

FIG. 208. — Wing of earwig.

The fore wings resemble the elytra of beetles but the hind wings are very different from those of any other insects. Figure 208 represents one of these; they are furnished with radiating veins which extend from a point some distance from the base of the wings. When the wing is not in use that part over which these veins extend is folded in plaits like a fan, after which the wing is folded twice crosswise.

The most distinctive feature of the earwigs is the form of the cerci which are forceps-like and usually prominent. They are usually larger in the male than in the female.

There are only about fifteen known species of earwigs in America north of Mexico and some of these are exotic forms which have come into the country through the channels of commerce.

The little earwig, *Lābia mīnor*, is only about $\frac{1}{5}$ of an inch long but it is widely distributed in the United States and has become established in Canada (Fig. 207).

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* Dermaptera: *derma* (δέρμα), skin; *pteron* (πτερόν), a wing.

The seaside earwig, *Anisolābis marĭtima*, which is about $\frac{4}{5}$ of an inch in length, is found along the Atlantic Coast from Maine to Texas. Both pairs of wings are absent in this species.

The handsome earwig, *Prolābia pulchĕlla*, is a shining chestnut-brown species found in the southern United States under the bark of dead trees. It is about $\frac{1}{4}$ of an inch in length.

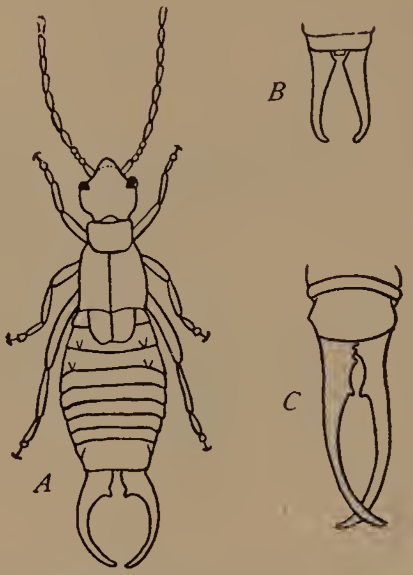

Fig. 209. — *A*, Male with short forceps; *B*, forceps of female; *C*, long type of forceps of male. (After Morse.)

The European earwig, *Forfĭcula auriculāria*, (Fig. 209), was found at Newport, Rhode Island, in 1911 and has now become established in the States of New York, Oregon, Washington and California. It is about $\frac{3}{4}$ of an inch in length and of a rich reddish-brown with the wing-covers and legs a dull yellowish-brown. This earwig is nearly omnivorous although it is especially injurious to flowers and green plants. It often occurs in great numbers and becomes a serious pest.

CHAPTER XX

ORDER COLEOPTERA *

The Beetles

The winged members of this order have four wings; but the wings of the first pair are greatly thickened, forming "wing-covers" or elytra, beneath which the membranous hind wings are folded when at rest. The elytra meet in a straight line along the middle of the back and serve as armor, protecting that part of the body which they cover. The mouth-parts are formed for chewing. The metamorphosis is complete.

The order Coleoptera includes only the beetles. These insects can be readily distinguished from all others except the earwigs by the structure of the fore wings, these being horny, veinless "wing-covers" or elytra, which meet in a straight line along the middle of the back (Fig. 210); and they differ from earwigs in lacking pincer-like appendages at the caudal end of the body. Beetles also differ from earwigs in having a complete metamorphosis.

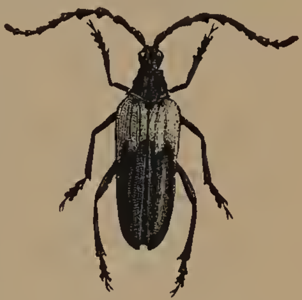
FIG. 210.

The hind wings are membranous, and in most species very efficient organs of flight. But in some of the pre-eminently running beetles the hind wings are wanting, and the elytra serve only as a protection to the abdomen. With some of these insects the elytra are even grown together where they meet on the middle line of the back; and in some of the Meloidæ the elytra do not meet in a straight line.

The venation of the wings of the Coleoptera has become greatly modified, and, consequently, the determination of the homologies of the wing veins is a difficult matter. The transformation of the fore wings into elytra has resulted in a great reduction of their venation; and the foldings of the hind wings interrupt the veins and cause distortions in their courses.

The different mouth-parts are very evenly developed; we do not find some of them greatly enlarged at the expense of others, as in several other orders of insects. The upper lip, or labrum, is usually distinct; the mandibles are powerful jaws fitted either for seizing prey or for gnawing; the maxillæ are also well developed and are quite complicated, consisting of several distinct pieces; the maxillary palpi are usually prominent; and the lower lip, or labium, is also well developed and complicated, consisting of several parts and bearing prominent labial palpi.

The larvæ are commonly called grubs. They are usually furnished with six thoracic legs, and often with a single proleg at the caudal end of the body; some, however, as the larvæ of the snout-beetles, are entirely destitute of jointed legs. The pupæ have the partially developed elytra, wings, and legs folded upon the breast, but in distinct sheaths (Fig. 211).

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* Cōleoptera: *coleos* (κολεός), a sheath; *pteron* (πτερόν), a wing.

These insects usually transform in rude cocoons made of earth or of bits of wood fastened together by a viscid substance excreted by the larvæ. Many wood-burrowing species transform in the tunnels made by the larvæ; and some of the dermestids as well as some of the lady-bugs transform in the last larval skin.

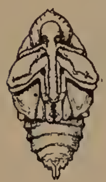

Fig. 211.

Both larvæ and adults present a very wide range of habits. While the majority of the species are terrestrial, the members of several families are aquatic; and while some feed on vegetable matter, others feed upon animal matter. The vegetable feeders include those that eat the living parts of plants, those that bore in dead wood, and those that feed upon decaying vegetable substances. Among the animal feeders are those that are predacious, those that feed on dried parts of animals, and those that act as scavengers, feeding on decaying animal matter. Viewed from the human standpoint, some species are very beneficial, others are extremely noxious.

In the classification of beetles much use is being made of the variations in form of the ventral and lateral sclerites of the thorax. Figure 215 will serve as an illustration of these sclerites. One feature merits special mention: the coxæ of the hind legs are flattened and immovably attached to the thorax so that they appear to be a part of the thorax instead of the basal segment of an appendage.

The Coleoptera is a very large order, the latest catalogue listing 18,547 species representing 109 families. The order is divided into two suborders, the Adephaga and the Polyphaga.

CLASSIFICATION OF THE COLEOPTERA

In order to use the table for determining the families of beetles it is necessary that the student should become familiar with certain terms not defined in the discussion of the external anatomy of insects. The following notes are therefore given as a supplement to that discussion.

The head. — One of the sclerites that enters into the composition of the external wall of the head is frequently referred to in descriptions of beetles; this is the gula. The *gula* is the central portion of the ventral wall of the head, and is the part which bears the labium (Fig. 212, *g*). The sutures which bound the gula, one on each side, are termed the *gular sutures* (Fig. 212, *gs*). In the Rhynchophora the gula appears to be wanting, and there is a single suture on the middle line of the head (Fig. 213, *gs.*)

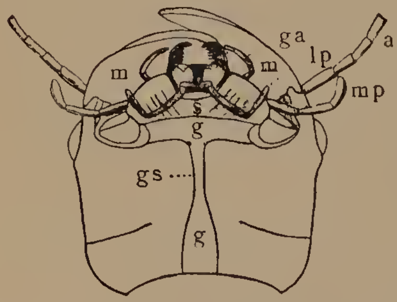

Fig. 212. — Head of *Harpalus*, ventral aspect: *a*, antenna; *g*, *g*, gula; *ga*, galea or outer lobe of the maxilla; *gs*, gular suture; *lp*, labial palpus; *m*, *m*, mandibles; *mp*, maxillary palpus; *s*, submentum.

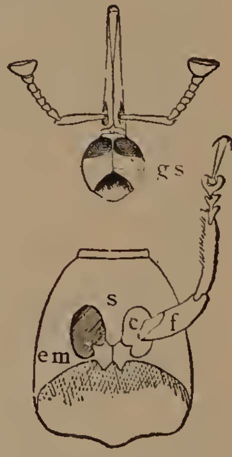

Fig. 213. — Head and prothorax of *Rhynchophorus*: *gs*, confluent gular sutures; *s*, prosternum; *em*, epimerum; *c*, coxa; *f*, femur.

The antennæ. — The more common types of antennæ have been described. In many insects however, the first segment of the antenna is long and the antenna is bent suddenly at the joint between the first and second segments; such antennæ are said to be elbowed or *geniculate*.

The mouth-parts. — Much use is made of the form of the parts of the *labium* or lower lip in descriptions of beetles. When fully developed the labium consists of three principal parts and a pair of appendages. The principal parts are the *submentum*, the *mentum*, and the *ligula*; the appendages are the *labial palpi*. The basal part of the labium, the part which is joined to the gula, is the *submentum* (Fig. 214, *sm*). By an unfortunate error this sclerite is almost invariably described in works on the Coleoptera as the *mentum*. This fact should be borne in mind by the student when using any of the older books on this subject. The intermediate portion of the labium is the *mentum* (Fig. 214, *m*); and the distal portion the *ligula*.

The ventral aspect of a beetle. — In the classification of beetles much use is made of certain sclerites and sutures present on the ventral side of the insect. The student should study Figure 215 to become familiar with these structures. In some beetles the metasternum is divided into two unequal portions by a suture which extends transversely a short distance in front of the caudal margin; the smaller sclerite which borders the posterior coxæ in front and often passes between them is called the *ante-coxal piece of the metasterum* (Fig. 215, *y*).

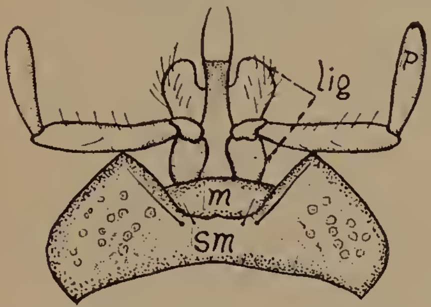

FIG. 214. — Labium of *Harpalus*: *sm*, submentum; *m*, mentum; *lig*, ligula; *P*, labial palpus.

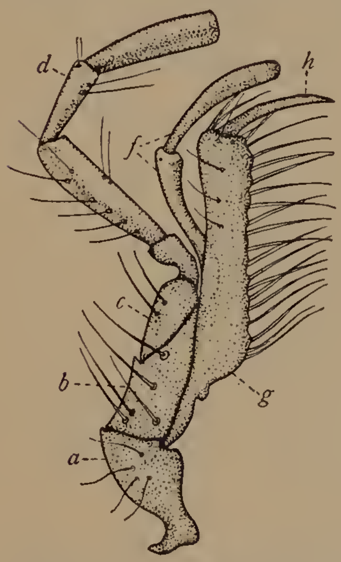

FIG. 214a. — Maxilla of beetle; *a*, cardo; *b*, stipes; *c*, palpifer; *d*, palpus; *f*, galea; *g*, lacinia; *h*, digitus.

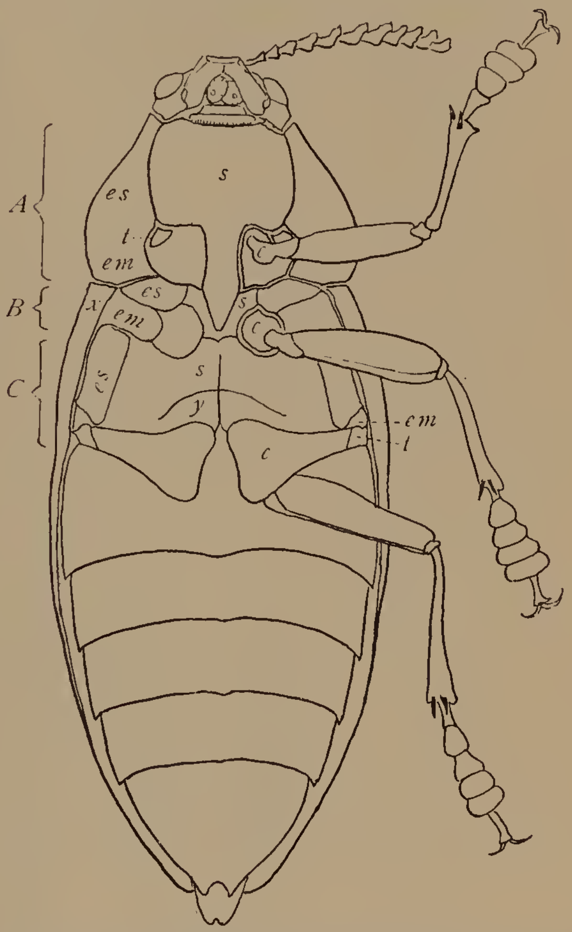

FIG. 215. — Ventral aspect of a beetle, *Enchroma gigantea*: *A*, prothorax; *B*, mesothorax; *C*, metathorax; *c*, *c*, *c*, coxæ; *em*, *em*, *em*, epimera; *es*, *es*, *es*, episterna; *s*, *s*, *s*, sterna; *t*, *t*, trochantins; *x*, elytrum; *y*, antecoxal piece of metasternum.

The openings in the thoracic segments in which the legs are inserted are termed the *coxal cavities*. Much use is made in the classification of beetles of the form of the coxal cavities of the prothorax. When the epimera of the prothorax extend behind the coxæ and reach the prosternum, the coxal cavities are said to be *closed* (Fig. 216); when the epimera do not extend behind the coxæ to the prosternum, the coxal cavities are described as *open* (Fig. 217).

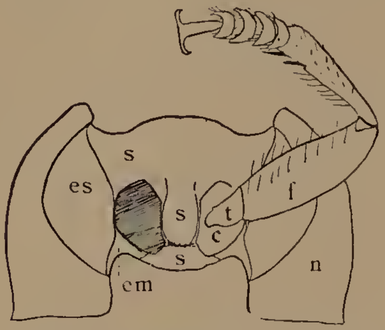

Fig. 216. — Prothorax of *Harpalus*, ventral aspect: *c*, coxa; *em*, epimerum; *es*, episternum; *f*, femur; *n*, pronotum; *s*, *s*, *s*, prosternum.

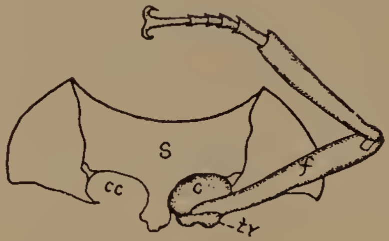

Fig. 217. — Prothorax of *Penthe*; *c*, coxa; *cc*, coxal cavity; *f*, femur; *s*, prosternum; *tr*, trochanter.

The tarsi of certain beetles. — In the suborder, Polyphaga, there is a group of beetles, the Phytophaga, in which the tarsi appear to be four-segmented. The fourth segment is a very small one situated deep in between the lobes of the third segment and is firmly united with the fifth segment (Fig. 218, *A*). Other types of tarsi in the series Palpicornia, Polyformia, and Clavicornia are shown in Figure 218.

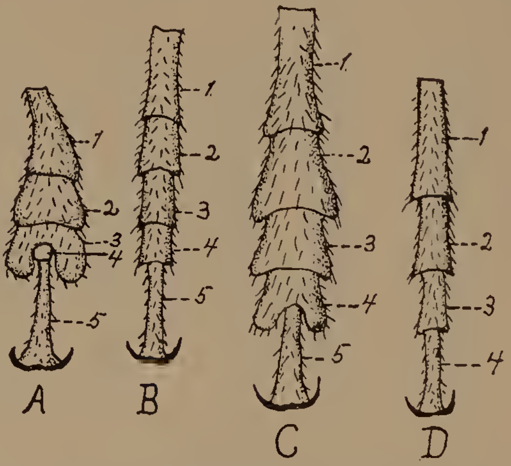

Fig. 218. — Tarsi of beetles: *A*, Phytophaga; *B*, *C*, *D*, of the series Palpicornia, Polyformia, and Clavicornia.

TABLES FOR DETERMINING THE FAMILIES OF THE COLEOPTERA DISCUSSED IN THIS MANUAL

TABLE I. — THE SUBORDERS

A. Ventral part of the first segment of the abdomen divided by the hind coxal cavities, so that the sides are separated from the very small medial part. Suture present between pronotum and episternum. Suborder ADEPHAGA; see Table II.

AA. Ventral part of the first segment of the abdomen visible for its entire breadth. Suture between pronotum and episternum not present. Suborder POLYPHAGA; See Table III.

TABLE II. — ADEPHAGA, THE FAMILIES OF THE SUBORDER

A. Metasternum with an antecoxal piece, separated by a well-marked suture reaching from one side to the other and extending in a triangular process between the hind coxæ. Hind coxæ mobile, and of the usual form; habits terrestrial; legs fitted for walking.

B. Antennæ inserted on the front above the base of the mandibles. p. 135. .... CICINDELIDÆ

BB. Antennæ arising at the side of the head between the base of the mandibles and the eyes. Beetles with long flat bodies and with the scutellum visible. p. 136 .... CARABIDÆ

AA. Metasternum without an antecoxal piece; legs fitted for swimming.

B. With only two eyes; antennæ filiform. p. 138 .... DYTISCIDÆ

BB. With four eyes, two above and two below; antennæ short and modified in form. p. 139 .... GYRINIDÆ

TABLE III. — POLYPHAGA, THE SERIES OF FAMILIES OF THE SUBORDER

A. Head not prolonged into a narrow beak, palpi always flexible; two gula sutures at least before and behind (Fig. 212); sutures between the prosternum and the episterna and epimera distinct (Fig. 216); the epimera of the prothorax not meeting on the middle line behind the prosternum (Fig. 216).

B. Abdomen with at least three corneous segments dorsally, and exposed more or less by the short elytra. Hind wings with simple, straight veins; antennæ variable, but never lamellate. Series BRACHELYTRA; see Table IV.

BB. Abdomen with at most two corneous segments dorsally, usually completely covered by the elytra; hind wings with veins in part connected by recurrent veins.

C. Antennæ clubbed or not, but if clubbed not lamellate.

D. Tarsi usually apparently four-jointed, the real fourth segment being reduced in size so as to form an indistinct segment at the base of the last segment, with which it is immovably united (Fig. 218, *A*); the first three segments of the tarsi dilated and brush-like beneath; the third segment bilobed. Series PHYTOPHAGA; see Table VII.

DD. Tarsi varying in form and in the number of the segments, but when five-jointed not of the type described under E above, the joint between the fourth and fifth segments being flexible. Series PALPICORNIA, POLYFORMIA, and CLAVICORNIA; see Table V.

CC. Antennæ with a lamellate club. Series LAMELLICORNIA; see Table VI.

AA. Head either prolonged into a beak or not; palpi usually short and rigid; gular sutures confluent on the median line (Fig. 213, *gs*); prosternal sutures wanting; the epimera of the prothorax meeting on the middle line behind the prosternum (Fig. 213, *em*). Series RHYNCHOPHORA; see Table VIII.

TABLE IV. — THE FAMILIES OF THE BRACHELYTRA

A. Elytra short, leaving the greater part of the abdomen exposed; the suture between the elytra when closed straight; wings present, and when not in use folded beneath the short elytra; the dorsal part of the abdominal segments entirely horny; abdomen flexible, and with seven or eight segments visible below; antennæ not clubbed at the ends. p 143 .... STAPHYLINIDÆ

AA. Elytra usually longer, covering the greater part of the abdomen; when short the wings are wanting or, if present, may or may not be folded under the short elytra when at rest; the dorsal part of the abdominal segments partly membranous; antennæ usually clubbed at the ends.

B. Hind tarsi five-segmented, antennæ rarely elbowed, abdomen with six or more ventral segments, anterior coxæ conical.

C. Posterior coxæ widely separated, eyes wanting or inconspicuous. p. 142. .... SILPHIDÆ

CC. Posterior coxæ approximate, and not laminate, eyes with small facets. p. 142.. SILPHIDÆ

BB. All tarsi four-segmented; hind coxæ contiguous and with plates covering the femora entirely or in part. p. 142............................ SILPHIDÆ

BBB. Hind tarsi with only four segments; the fore tarsi, and almost always the middle tarsi with five segments. p. 142........................ SILPHIDÆ

TABLE V. — THE FAMILIES OF THE PALPICORNIA, POLYFORMIA, AND CLAVICORNIA *

It is impracticable to separate these three series of families in these tables, owing to the fact that characters sharply separating them have not been found.

A. Hind tarsi five-jointed.

B. Maxillary palpi as long as or longer than the antennæ. p. 141.... HYDROPHILIDÆ

BB. Maxillary palpi much shorter than the antennæ.

C. Tarsal claws very large; the first three abdominal segments grown together on the ventral side........................ *Psephenidæ, Dryopidæ, Elmidæ*

CC. Tarsal claws of usual size; ventral abdominal segments usually free, sometimes (Buprestidæ) the first two grown together.

D. Abdomen with not more than five ventral segments.

E. Femur joined to the apex or very near the apex of the trochanter. .... *Ptinidæ, Anobiidæ, Bostrichidæ, Lyctidæ*

EE. Femur joined to the side of the trochanter.

F. Anterior coxæ globular or transverse, usually projecting but little from the coxal cavity.

G. Anterior coxæ transverse, more or less cylindrical, posterior coxæ grooved for the reception of the femora. .... *Nosodendridæ, Byrrhidæ, Chelonariidæ, et al.*

GG. Anterior coxæ globular.

H. Prosternum with a process which extends backward into a groove in the mesosternum.

I. Eye continuing the general line of the head, the head usually buried in the thorax up to the eye. Prothorax closely dovetailed into mesothorax below. First ventral suture of abdomen much weaker than the others, usually partly lost. p. 148. .... BUPRESTIDÆ

II. Eye usually prominent, frequently separated by a space from prothorax; articulation between pro- and mesothorax usually freely movable; first *three* ventral sutures of abdomen similar and deep. (*Not* movable as usually reporte.) p. 147... ELATERIDÆ

HH. Prosternum without a process received by the mesosternum, although it may be prolonged so as to meet the mesosternum.

I. Posterior coxæ contiguous........................ *Phalacridæ*

II. Posterior coxæ separated.

J. Body depressed; middle coxal cavities not closed externally by a meeting of the mesosternum and metasternum. p. 152. .... CUCUJIDÆ

JJ. Body more or less convex; middle coxal cavities entirely surrounded by the sterna. .... *Mycetophagidæ, Cryptophagidæ, Erotylidæ*

FF. Anterior coxæ conical, and projecting prominently from the coxal cavity.

G. Posterior coxæ dilated into plates partly protecting the femora, at least at their bases.

H. Antennæ serrate or flabellate...................... *Rhipiceridæ*

HH. Antennæ with the last three segments forming a large club.

I. Tarsi with second and third segments lobed beneath.... *Byturidæ*

II. Tarsi simple. p. 150............................ DERMESTIDÆ

DD. Abdomen with six or more ventral segments.

E. Anterior coxæ globular........................ *Cebrionidæ, Plastoceridæ*

EE. Anterior coxæ conical.

* Families italicized are not discussed in this manual.

F. Posterior coxæ not prominent, flat, covered by the femora in repose. .... *Cleridæ, Corynetidæ*
FF. Posterior coxæ more or less conical and prominent at least internally, not covered by the femora in repose.
G. Anterior coxæ long, with distinct trochantins.
H. Abdomen with seven or eight ventral segments.
I. Middle coxæ contiguous; epipleuræ distinct.
J. Episterna of metathorax sinuate on inner side, epipleuræ usually wide at the base.
K. Head more or less covered; antennæ approximate or moderately distant; metathoracic epimera long. p. 144. .... LAMPYRIDÆ
KK. Head exposed; antennæ distant; metathoracic epimera wide .... *Phengodidæ*
JJ. Episterna of metathorax not sinuate on the inner side; epipleuræ narrow at the base. p. 145 .... CANTHARIDÆ
AA. Hind tarsi either only three-jointed, or four-jointed but apparently only three-jointed, the third joint being small and concealed in a notch at the end of the second joint. (See also AAA.)
B. Wings fringed with long hairs. A minute aquatic species from S. Cal. and Ariz. (*Hydroscapha.*) p. 141 .... HYDROPHILIDÆ
BB. Wings not fringed with hairs.
C. Tarsi with second segment dilated.
D. Tarsal claws appendiculate or toothed; first ventral abdominal segment with distinct curved coxal lines. p. 152 .... COCCINELLIDÆ
DD. Tarsal claws simple; first ventral abdominal segment without coxal lines .... *Endomychidæ*
AAA. Hind tarsi with only four segments; the fore tarsi, and almost always the middle tarsi also, with five segments.
B. Anterior coxal cavities closed behind.
C. Tarsal claws simple.
D. Abdomen with five ventral segments.
E. Ventral abdominal segments in part grown together.
F. Next to the last segment of the tarsi spongy beneath .... *Lagriidæ*
FF. Penultimate segment of tarsi not spongy. p. 151 ...... TENEBRIONIDÆ
BB. Anterior coxal cavities open behind.
C. Head not strongly and suddenly constricted at base.
D. Middle coxæ not very prominent, antennæ free.
E. Prothorax margined at the sides.
F. Middle coxal cavities entirely surrounded by the sterna. .... *Cryptophagidæ*
FF. Epimera of mesothorax reaching the coxæ.
G. Metasternum long; epimera of metathorax visible .. *Melandryidæ*
GG. Metasternum quadrate; epimera of metathorax covered. p. 152. .... CUCUJIDÆ
EE. Prothorax not margined at the sides .... *Pythidæ*
DD. Middle coxæ very prominent .... *Œdemeridæ*
CC. Head strongly constricted at base.
D. Head prolonged behind and gradually narrowed .... *Cephaloidæ*
DD. Head suddenly narrowed behind.
E. Prothorax with the side pieces not separated from the pronotum by a suture.
F. Prothorax at base narrower than the elytra.
G. Hind coxæ not prominent or but slightly so, anterior coxæ globular, not prominent. p. 152 .... CUCUJIDÆ
GG. Hind coxæ large, prominent.
H. Tarsal claws simple; head horizontal .... *Pyrochroidæ*
HH. Claws cleft or toothed, front vertical. p. 145 ...... MELOIDÆ

TABLE VI. — THE FAMILIES OF THE LAMELLICORNIA

A. Plates composing the club of the antennæ flattened and capable of close apposition.
B. Abdomen with six visible ventral segments. p. 154 .... SCARABÆIDÆ
BB. Abdomen with five visible ventral segments.

C. Epimera of mesothorax attaining the oblique coxæ. p. 154 . . . . SCARABÆIDÆ
CC. Epimera of mesothorax not attaining the coxæ. p. 159 . . . . TROGIDÆ
AA. Plates composing the club of the antennæ not capable of close apposition, and usually not flattened.
B. Mentum deeply emarginate, ligula filling the emargination. p. 160 . . PASSALIDÆ
BB. Mentum entire, ligula covered by the mentum or at its apex. p. 159. . . . . LUCANIDÆ

TABLE VII. — FAMILIES OF THE PHYTOPHAGA

This series includes three families, which are so connected by intermediate forms that it is not easy to separate them. The following table will aid the student in separating the more typical forms.

A. Body elongate; antennæ almost always long, often as long as the body or longer. The larvæ are borers. p. 160 . . . . CERAMBYCIDÆ
AA. Body short and more or less oval; antennæ short.
B. Front prolonged into a broad quadrate beak; elytra rather short so that the tip of the abdomen is always exposed. The larvæ live in seeds. p. 167. . . . . MYLABRIDÆ
BB. Front not prolonged into a beak; usually the tip of the abdomen is covered by the elytra. Both larvæ and adults feed on the leaves of plants. p. 164. . . . . CHRYSOMELIDÆ

TABLE VIII. — THE FAMILIES OF THE RHYNCHOPHORA

(*Compiled from Blatchley and Leng*)

A. Beak rarely absent, usually longer than broad; tibiæ never with a series of teeth externally.
B. Antennæ straight without a distinct club, though with the outer joints often more or less thickened; beak present at least in the female and pointing dircetly forward; form usually very slender and elongate. p. 169 . . . BRENTIDÆ
BB. Antennæ straight or elbowed, always with a distinct club.
C. Palpi flexible; antennal club rarely compact; beak always short and broad; labrum present; thorax with a transverse raised line which is either antebasal or basal. p. 169 . . . . PLATYSTOMIDÆ
CC. Palpi rigid and labrum wanting except in the subfamily, Rhinomacerinæ antennal club usually compact; beak variable in length, often long and curved downwards. p. 169 . . . . CURCULIONIDÆ
AA. Beak absent or extremely short and broad; tibiæ with a series of teeth externally, or, if these are wanting, with a prominent curved spine at apex; antennæ short, but little longer than the head, always elbowed, and with a compact club except in *Phthorophlœus* where the club is lamellate; palpi rigid; body short, subcylindrical or rarely oval.
B. Anterior tarsi with the first segment longer than the second, third and fourth together. p. 171 . . . . PLATYPODIDÆ
BB. Anterior tarsi with the first segment shorter than the second, third, and fourth together. p. 172 . . . . SCOLYTIDÆ

THE CARNIVOROUS BEETLES

Suborder ADEPHAGA *

The name of this suborder, Adephaga, was suggested by the predacious habits of its members. These beetles are distinguished from other Coleoptera by the presence of a suture on each side of the prothorax separating the pleurum from the notum, and by the fact that the ventral part of the first segment of the abdomen is divided by the hind coxal cavities so that the sides are separated from the very small medial part (Fig. 219).

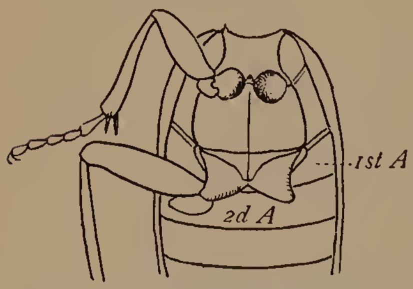

FIG. 219. — Ventral aspect of part of thorax and abdomen of *Galerita janus*: *1st A*, first abdominal segment; *2d, A*, second abdominal segment.

The larvæ are campodeiform, and differ from all other beetle larvæ in

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* Adĕphaga: *adephagous* (ἀδηφάγος), voracious.

that their legs are six-jointed except in a single exotic species; this is one more segment than is found in the legs of other beetle larvæ. The legs are usually furnished with two claws, whereas the legs of other coleopterous larvæ are one-clawed.

This suborder is represented in North America by less than ten families.

Family Cicindelidæ

The Tiger-beetles

The graceful forms and beautiful colors of the greater number of the tiger-beetles, those of the genus *Cicindela*, have made the family one of the favorites of students of Coleoptera. Their popular name is suggestive of their predacious habits, and of the stripes with which many are marked. They are usually a metallic green or bronze, banded or spotted with yellow. Some are black; and some that live on white sand are grayish-white, being exactly like the sand in color. Figure 220 represents a common species of *Cicindela*.

A useful character for distinguishing the members of this family is the fact that the terminal hook of the maxilla (the digitus) is united to this organ by a movable joint (Fig. 221, *h*).

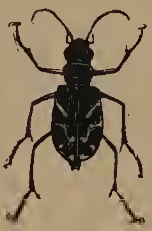
Fig. 220.

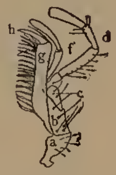

Fig. 221.

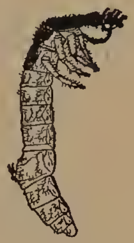
Fig. 222.

The tiger-beetle larvæ (Fig. 222) are as ugly and ungraceful as the adults are beautiful. The two have only one habit in common — their eagerness for prey. The larvæ live in vertical burrows in sandy places or in beaten paths. These burrows occur also in ploughed fields that have become dry and hard. They often extend a foot or more in depth. The larva takes a position of watchfulness at the mouth of its burrow. Its dirt-colored head is bent at right angles to its lighter-colored body and makes a neat plug to the opening of the hole. Its rapacious jaws extend upward, wide open, ready to seize the first unwary insect that walks over this living trap, or near it; for a larva will throw its body forward some distance in order to seize its prey. On the fifth segment of the abdomen there is a hump, and on this hump are two hooks curved forward. This is an arrangement by which the little rascal can hold back and keep from being jerked out of its hole when it gets some large insect by the leg, and by which it can drag its struggling prey down into its lair, where it may eat it at leisure. It is interesting to thrust a straw down into one of these burrows, and then dig it out with a trowel. The chances are that you will find the indignant inhabitant at the remote end of the burrow, chewing savagely at the end of the intruding straw.

One hundred and fourteen species of tiger-beetles are now listed in our fauna; these represent four genera, the principal one of which is the genus *Cicindela* containing at least 76 species and many varieties.

The members of this genus, unlike most other members of the family, are diurnal in habit. They are found on bright, hot days in dusty roads, in beaten paths, and on the shores of streams. They are the most agile of all beetles; and they are not merely swift of foot, but are also able to fly well. When approached, they remain still until we can see them well but are still out of reach; then like a flash they fly up and away, alighting several rods ahead of us. Before alighting they usually turn so that they face us, and can thus watch our movements. They hide by night and in cloudy or rainy weather in holes in the ground or beneath stones or rubbish. The beetles have been found hibernating, each in a separate burrow extending under a stone. We have seen them in September digging burrows in a hillside; these descended slightly and were about five inches deep. The beetles kicked the dirt out behind them as they dug, so that it lay in a heap at the opening of the hole.

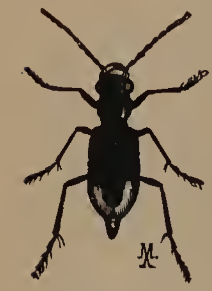
FIG. 223. — *Tetracha carolina.*

There are two species of the genus *Tĕtracha* (Fig. 223) widely distributed in the United States. The species, *Amblycheila cylindrifŏrmis*, found from Kansas to New Mexico is a very large one for it is nearly 1½ inches long. Over thirty species of the genus *Omus* are found along the Pacific coast. These beetles are nocturnal: they search for their prey at night.

Family CARABIDÆ

The Ground-beetles

The ground-beetles are so called because they are very common on the surface of the ground, lurking under stones or rubbish, where they hide by day. At night they roam about in search of their prey. Our more common species are easily recognized by their shining black color and long legs. On the Pacific Coast, however, the darkling beetles (Family Tenebrionidæ), which are also black and have long legs, abound under stones and fragments of wood on the ground. But the two families can be easily distinguished by the fact that in the ground-beetles all the tarsi are five-jointed, while in the darkling beetles the hind tarsi are only four-jointed; and the darkling beetles do not run rapidly as do the ground-beetles.

With the ground-beetles, the antennæ are thread-like, tapering gradually towards the tip, and each segment is of nearly uniform thickness throughout its length; the legs are fitted for running, and the antennæ are inserted between the base of the mandibles and the eyes. Although most of the species are black, there are those that are blue, green, or brown, and a few that are spotted. The wing-covers are almost always ornamented with longitudinal ridges and rows of punctures.

Most members of this family are predacious, feeding upon other insects, which they spring upon or capture by chase. A few species use vegetable food; but their depredations are rarely of economic importance. As there are more than two thousand described North American species, and as many of the species are very common, this family may be considered the most important family of the predacious insects.

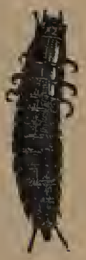
FIG. 224.

The larvæ of ground-beetles are generally long, with the body of nearly equal breadth throughout (Fig. 224). They have sharp projecting mandibles; and the caudal end of the body is usually furnished with a pair of conical bristly appendages. They live in the same obscure situations as the adult insects, but are more shy, and are consequently less frequently seen. Like the adults, they are predacious.

Among the more common ground-beetles are the following.

The searcher, *Calosōma scrutātor.* — This is one of the larger and more beautiful of our ground-beetles; it has green or violet wing-covers margined with reddish, and the rest of the body is marked with violet-blue, gold, green, and copper (Fig. 225). This beetle and the two following have been known to climb trees in search of caterpillars.

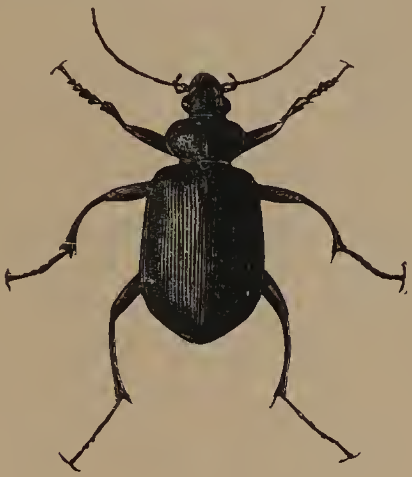

Fig. 225.

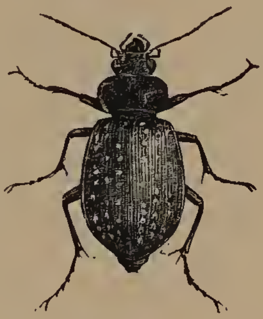

Fig. 226

Calosōma sycophănta, a common species in Europe, has been introduced and successfully colonized in New England, as a means of combating the gipsy-moth and the brown-tail moth. This species is somewhat smaller than the preceding, and lacks the reddish band on the margins of the elytra.

The fiery hunter, *Calosōma călidum*, is easily recognized by the rows of reddish or copper-colored pits on the wing-covers (Fig. 226).

The bombardier-beetles, *Brachīnus.* — There are many species of beetles that have at the hind end of the body little sacs in which is secreted a bad-smelling fluid, which is used as a means of defence. These beetles spurt this fluid out onto their enemies when attacked. But in the case of the bombardier-beetles this fluid changes to a gas, which looks like smoke as soon as it comes in contact with the air, and is ejected with a sound like that of a tiny pop-gun. When some larger insect tries to capture one of these insect-soldiers, and gets very near it, the latter fires its little gun into the face of its enemy. The noise astonishes the pursuer, and the smoke blinds him. By the time he has recovered from his amazement, the little bombardier is at a safe distance. These beetles have quite a store of ammunition; for we have often had one pop at us four or five times in succession, while we were taking it prisoner. The bombardier-beetles belong to the genus *Brachinus*, of which we have in this country twenty-seven species. They are very similar in appearance; the head, prothorax, and legs are reddish-yellow, and the wing-covers are dark blue, blackish, or greenish-blue (Fig. 227).

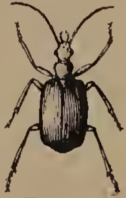

Fig. 227.

There is a common beetle which resembles the bombardier-beetles quite closely in size and color, but which may be distinguished by the comb-like form of the tarsal claws; this is *Lebia grandis* (Fig. 228). It has been reported more often than any other insect as destroying the Colorado potato-beetle.

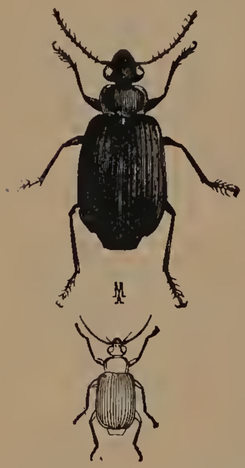

FIG. 228. — *Lebia grandis*, natural size and enlarged

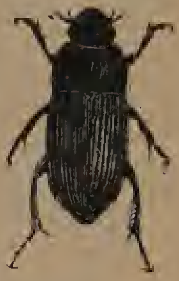

FIG. 229.

What is perhaps the most common type of ground-beetle is illustrated by *Hărpalus caliginōsus*, which is represented natural size in Figure 229. It is of a pitchy black color, and is one of the most common of our larger species. There are one hundred and thirty-six described species of *Harpalus* in this country. Most of them are smaller than this one, are flattened, and have the prothorax nearly square.

The most common of all ground-beetles, in the Northeastern States at least, is *Pœcilus lucublăndus*. In this species (Fig. 230) the narrow, flat margin on each side of the prothorax is widened near the hind angle of this segment.

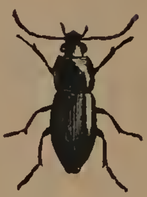

FIG. 230.

Family DYTISCIDÆ

The Predacious Diving-Beetles

If one will approach quietly a pool of standing water, there may be seen oval, flattened beetles hanging head downward, with the tip of the abdomen at the surface of the water. Such beetles belong to this family.

The predacious diving-beetles are usually brownish black and shining, but are often marked indefinitely with dull yellow. They can be distinguished from the water scavenger-beetles, which they resemble in general appearance, by the thread-like form of the antennæ. The hind legs are the longest and are fitted for swimming, being flattened and fringed with hair. The middle and the hind pair of legs are widely separated. In the males of certain genera the first three segments of the fore tarsi are dilated and form a circular disk, upon the under side of which are little cup-like suckers (Fig. 231). The females of some species exhibit an interesting dimorphism in that some of the individuals have the elytra furnished with a number of deep furrows (Fig. 232), while others of the same species have them smooth.

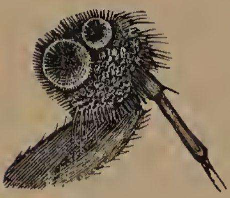

FIG. 231.

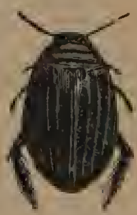

FIG. 232.

The diving-beetles abound in our streams and ponds, but they are more often found in standing water than in streams. When at rest they float in an inclined position, head downward, with the tip of the hind end of the body projecting from the water. The spiracles open on the dorsal side of the abdomen beneath the elytra. By lifting the elytra slightly a reservoir is formed for air, which the beetle can breathe as it swims through the water. When the air becomes impure the beetle rises to the surface, forces it out, and takes a fresh supply.

These beetles are very voracious. They destroy not only other insects, but some of them will attack larger animals, as small fish. When kept in aquaria they can be fed upon any kind of meat, raw or cooked. They fly from pond to pond, and are often attracted to light at night. Many of the species make sounds, both under the water and in the air. In some cases this is done by rubbing the abdominal segments upon the elytra; in others, by rubbing the hind legs upon a rough spot on the lower side of the abdomen.

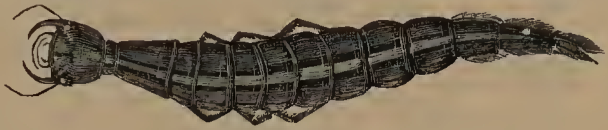
FIG. 233.

The females deposit their eggs singly in punctures in the tissues of living plants. The larvæ are known as water-tigers, because of their blood-thirstiness. They are elongated, spindle-form grubs (Fig. 233). The head is large, oval or rounded, and flattened; the mandibles are large and sickle-shaped; in each there is a slit-like opening near the tip; from this opening a canal leads along the inner surface to a basal opening on the upper surface, which communicates with the corner of the mouth when the mandible is closed. The mandibles are admirably fitted for holding prey and at the same time sucking juices from its body. The thorax is furnished with six well-developed legs. The abdomen is terminated by a pair of processes; at the tip of the abdomen there is a pair of large spiracles, which the larva protrudes into the air at intervals, in order to breathe.

When a larva is fully grown it leaves the water, burrows into the ground, and makes a round cell, within which it undergoes its transformations. The pupa state lasts about three weeks in summer; but the larvæ that transform in autumn remain in the pupa state all winter.

This is the largest of the families of water-beetles; more than three hundred North American species are known.

The best way to obtain specimens is to sweep the vegetation growing on the bottom of a quiet pool with a dip-net.

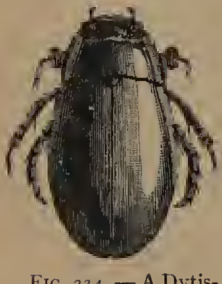
FIG. 234. — A Dytiscus beetle.

The larger of our common species belong to *Cybĭster*, *Dytĭscus* (Fig. 234), and allied genera.

The most common of the diving-beetles which are of medium size belong to the genus *Acĭlius*.

There are also common diving-beetles which are of about the same size as the preceding, but which have the wing-covers marked with numerous very fine transverse striæ; these belong to the genus *Colymbētes*.

Of the smaller diving-beetles, measuring less than $\frac{1}{4}$ of an inch in length, many species can be found in almost any pond. These represent many genera.

Family GYRINIDÆ

The Whirligig-beetles

As familiar to the country rover as the gurgling of the brook or the flecks of foam on its "golden-braided centre," or the trailing ferns and the rustling rushes on its banks, are these whirligigs on its pools. Around and around each other they dart, tracing graceful curves on the water, which vanish almost as soon as made. They are social fellows, and are almost always found in large numbers, either swimming or resting motionless near together. They rarely dive, except when pursued; but are so agile that it is extremely difficult to catch them without a net. Many of them when caught exhale a milky fluid having a very disagreeable odor. They feed upon small flies, beetles, and other insects that fall into the water, and are furnished with well-developed wings, with which they fly from one body of water to another.

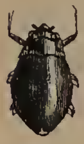
Fig. 235.

This is one of the most easily-recognized families of the whole order Coleoptera. The members of it are oval or elliptical in form (Fig. 235), more or less flattened, and usually of a very brilliant bluish-black color above, with a bronze metallic lustre. The fore legs are very long and rather slender; the middle and hind legs are short, broad, and very much flattened. These insects are remarkable for having the eyes completely divided by the margin of the head, so that they appear to have four eyes — a pair upon the upper surface of the head with which to look into the air, and a pair upon the under side for looking into the water. The antennæ are very short and peculiar in form. The third segment is enlarged, so as to resemble an ear-like appendage, and the following ones form a short spindle-shaped mass. They are inserted in little cavities in front of the eyes.

The eggs of these insects are small, of cylindrical form, and are placed end to end in parallel rows upon the leaves of aquatic plants. The larvæ (Fig. 236) are long, narrow, and much flattened. Each abdominal segment is furnished with a pair of tracheal gills, and there is an additional pair at the caudal end of the body. The elongated form of the body and the conspicuous tracheal gills cause these larvæ to resemble small centipedes. When a larva is full-grown it leaves the water and spins a gray, paper-like cocoon attached to some object near the water. The pupa state of those species in which it has been observed lasts about a month.

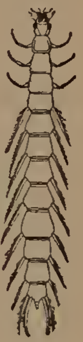
Fig. 236.

The family is a small one. At present only forty-one North American species are known. These represent three genera. The genus *Gyretes* is distinguished by having the last ventral segment of the abdomen elongated and conical. It is represented by two species. In the other two genera the last ventral segment is flattened and rounded at the tip. In *Dineūtus* the scutellum is invisible; there are thirteen species of this genus. In *Gyrīnus* the scutellum is visible; of this genus we have twenty-six species.

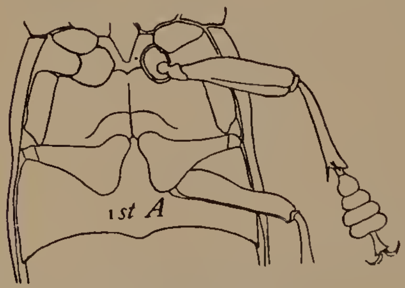

Fig. 237. — Ventral aspect of part of thorax and abdomen of *Enchroma gigantea*: *1st A*, first abdominal segment.

THE HERBIVOROUS BEETLES

Suborder POLYPHAGA *

In the suborder Polyphaga the ventral part of the first segment of the abdomen is visible for its entire breadth (Fig. 237); the first three ventral segments are immovably united (except in the Cupesidæ), and the notum of the prothorax is not separated from the pleura by distinct sutures.

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* Polyphaga: *polyphagus*, eating many kinds of food.

The larvæ vary greatly in form; some are campodeiform, some are scarabeiform, and others are vermiform; in none are the legs more than five-jointed, and in none are the legs two-clawed.

This suborder includes all but the few preceding families of the Coleoptera.

Family Hydrophilidæ

The Water-scavenger Beetles

The water-scavenger beetles are common in quiet pools, where they may be found swimming through the water, or crawling among the plants growing on the bottom. They can be easily taken by sweeping such plants with a dip-net.

They are elongated, elliptical, black beetles, resembling the predacious diving-beetles in appearance; but they are usually more convex, and differ also in having club-shaped antennæ and very long palpi. As the antennæ are usually concealed beneath the head, it often happens that the inexperienced student mistakes the long palpi for antennæ.

These beetles are supposed to live chiefly upon the decaying vegetation in the water; but a number of species have been known to catch and eat living insects. They breathe by carrying a film of air on the lower surface of the body. This film gives them a silvery appearance when seen from below. They obtain the air by bringing the head to the surface of the water and projecting the antennæ, which they again fold back with a bubble of air when they descend. The female makes a case for her eggs out of a hardened silk-like secretion. Some species deposit as many as a hundred eggs in one of these water-proof packages (Fig. 238). The egg-cases in some instances are fastened beneath the leaves of aquatic plants; in others they are provided with floats and let loose in the water; and in still other species the cases are carried by the mother underneath her body and steadied with her hind legs. Frequently some of the young larvæ devour their companions; in this way the size of the family is decreased before it escapes from the egg-case. Later they live upon insects that fall into the water, and upon snails. These larvæ resemble somewhat those of the Dytiscidæ; but the body is much more plump, and the mandibles are of moderate size.

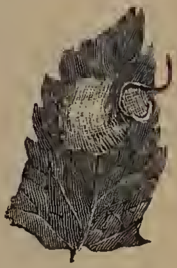

Fig. 238.

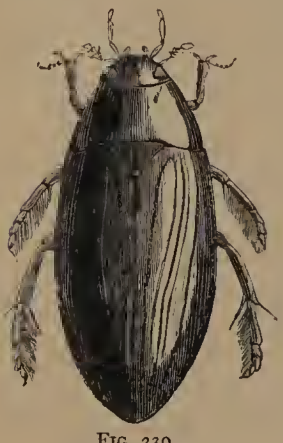

Fig. 239.

The family Hydrophilidæ is represented in North America by one hundred and ninety species. The largest of our common species is *Hȳdrous triangulāris* (Fig. 239). In the genus *Hydrous* the metasternum is prolonged backward into a spine between the hind legs, and the sternum of the prothorax bears a deep furrow.

Next in size to *Hydrous* are several species of *Hydrŏphilus*. In this genus the metasternum is prolonged somewhat, but does not form a long, sharp spine as in *Hydrous* and the sternum of the prothorax bears a keel-shaped projection. Our most common species is *Hydrophilus obtusātus;* this measures about $\frac{3}{5}$ of an inch in length.

Some of the smaller species of this family are not aquatic, but live in moist earth and in the dung of cattle, where, it is said, they feed on dipterous larvæ.

Family SILPHIDÆ

The Carrion-beetles

The carrion-beetles are mostly of medium or large size, many species attaining the length of $1\frac{3}{5}$ inches while the smaller species of the more typical genera are nearly $\frac{1}{2}$ inch in length; some members of the family, however, are minute. The segments near the tip of the antennæ are usually enlarged so as to form a compact club, which is neither comblike nor composed of thin movable plates; sometimes the antennæ are nearly filiform.

These insects usually feed upon decaying animal matter; some, however, feed upon fungi; some on vegetables; and a few species have been known to be predacious when pressed by hunger, destroying living snails and insects, even members of their own species; while a few occur only in the nests of ants.

It is easy to obtain specimens of these insects by placing pieces of meat or small dead animals in the fields and examining them daily. There are several other families of beetles the members of which can be attracted in this way.

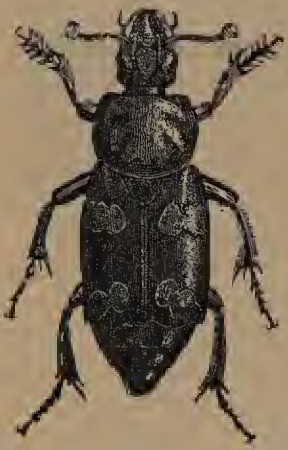
FIG. 240.

The larvæ also live upon decaying flesh and are found in the same situations as the adults.

We have in this country more than one hundred species of this family. Our larger and more familiar species represent two genera, *Necrŏphorus* and *Sĭlpha.*

The burying-beetles, *Necrŏphorus.* — To this genus belong the larger members of the family. The body is very stout, almost cylindrical (Fig. 240). Our common species have a reddish spot on each end of each wing-cover; these spots are often so large that they appear as two transverse bands. In some species the prothorax and the head are also marked with red.

These insects are called burying-beetles because they bury carrion. When a pair of these beetles discover a dead bird, mouse, or other small animal, they dig beneath it, removing the earth so as to allow the carrion to settle into the ground. This they will continue until the object is below the surface of the ground. Then they cover it with earth, and finally the female digs down to it and lays her eggs upon it. The larvæ that hatch from these eggs feed upon the food thus provided for them. There are many accounts of exhibitions of remarkable strength and sagacity by burying-beetles. A pair of these insects have been known to roll a large dead rat several feet in order to get it upon a suitable spot for burying.

The members of the genus *Sĭlpha* are very much flattened (Fig. 241). The prothorax is round in outline, with very thin edges which overlap the wing-covers somewhat. The body is not nearly as stout as that of a burying-beetle, being fitted for creeping under dead animals instead of for performing deeds requiring great strength. *Silpha bituberōsa*, which is known as the spinach carrion-beetle, feeds on spinach, beets, and other plants, in the West.

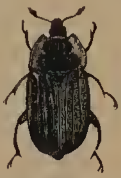

Fig. 241.

In some of the minute members of this family the body is nearly hemispherical.

Family Staphylinidæ

The Rove-beetles

The rove-beetles are very common about decaying animal matter, and are often found upon the ground, under stones or other objects. They are mostly very small insects; a few species, however, are of larger size, measuring $\frac{1}{2}$ inch or more in length. Their appearance is very characteristic, the body being long and slender, and the wing-covers very short (Fig. 242). The wings, however, are fully developed, often exceeding the abdomen in length; when not in use the wings are folded beneath the short wing-covers. The abdominal segments are freely movable.

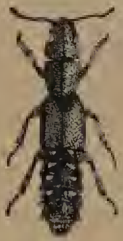

Fig. 242.

It is interesting to watch one of these insects fold its wings; frequently they find it necessary to make use of the tip of the abdomen or of one of the legs in order to get the wings folded beneath the wing-covers.

The rove-beetles can run quite swiftly; and they have the curious habit, when disturbed, of raising the tip of the abdomen in a threatening manner, as if they could sting. As some of the larger species resemble wasps somewhat in the form of the body, these threatening motions are often as effective as if the creatures really had a sting. William Beebe states (*Atlantic Monthly*, October, 1919) that when some rove-beetles were attacked by ants they raised their tails and ejected a drop or two of a repellent fluid which drove the ants away. This observation indicates the probable explanation of the actions of these beetles when disturbed.

As these insects feed upon decaying animal and vegetable matter, they should be classed as beneficial. The larvæ resemble the adults in the form of the body and are found in similar situations, about decaying animal and vegetable matter, beneath bark and in fungi. Some species are guests in the nests of ants, and others in the nests of termites.

Nearly three thousand North American species of rove-beetles have been described. The great majority are small and exceedingly difficult to determine. Among the large species that are common are the following.

Creŏphilus maxillōsus. — This species varies from $\frac{1}{2}$ an inch to nearly an inch in length. It is of a shining black color, spotted with patches of fine gray hairs. There is a conspicuous band of these across the middle of the wing-covers, and another on the second and third abdominal segments; this abdominal band is best marked on the lower side of the body.

Staphylīnus maculōsus is a larger species, which often measures fully an inch in length. It is densely punctured, and of a dull brown color, with the scutellum black, and a row of obscure, square, blackish spots along the middle of the abdomen.

Staphylīnus vulpīnus resembles the preceding somewhat, but it has a pair of bright yellow spots at the base of each abdominal segment.

Ontholĕstes cingulātus is of about the same size as the preceding. It is brown, speckled with brownish-black spots, and the tip of its abdomen is clothed with golden hairs.

Family Lampyridæ

The Firefly Family

During some warm, moist evening early in our northern June we are startled to see here and there a tiny meteor shoot out of the darkness near at hand, and we suddenly realize that summer is close upon us, heralded by her mysterious messengers, the fireflies. A week or two later these little torch-bearers appear in full force, and the gloom that overhangs marshes and wet meadows, the dusk that shrouds the banks of streams and ponds, the darkness that haunts the borders of forests, are illumined with myriads of flashes as these silent, winged hosts move hither and thither under the cover of the night.

The fireflies are soft-bodied beetles of medium or small size, with slender, usually eleven-jointed, saw-like antennæ. The prothorax is expanded into a thin projecting margin, which in most cases completely covers the head (Fig. 243). The wing-covers are rather soft, and never strongly embrace the sides of the abdomen, as with most other beetles.

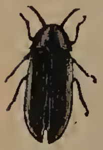

Fig. 243.

The fireflies are nocturnal insects and are sluggish by day. The property of emitting light is possessed by adults of both sexes and by larvæ. The latter and the wingless females of certain species are known as glow-worms. The light-organs of the winged adults are situated on the lower side of one or more of the abdominal segments; but they are lacking in some genera.

There have been many speculations as to the usefulness of the light-producing power of various organisms to the organisms themselves; and as regards many of these photogenic creatures no definite conclusions have been reached. But there is considerable evidence to show that in the case of adult lampyrids it serves to enable these insects to find their mates. It has been found that females enclosed in a perforated opaque box do not attract males, while those enclosed in a glass vial do; thus showing that it is the light emitted by the female, and not its odor, that attracts the male. It has also been shown that in some cases at least there are specific differences in the method of flashing which enables the insects to distinguish at a distance their proper mates.

Family Cantharidæ

The Soldier-Beetles and others

The family Cantharidæ includes those genera that were formerly included in the family Lampyridæ as the subfamily Telephorinæ.

The application of the name Cantharidæ to this family is the result of one of those unfortunate changes in generic names rendered necessary by our code of nomenclature. In this case the change is especially unfortunate, as the generic name *Cantharis* has been commonly applied to certain blister-beetles and is used in that sense in many medical works and in most text-books of entomology. The change is sure to result in much confusion.

The most common members of this family are the soldier-beetles, *Chauliŏgnathus*. These are very abundant in late summer and autumn on various flowers, but especially on those of goldenrod. The most common species in the East are the Pennsylvania soldier-beetle, *Chauliŏgnathus pennsylvănicus*, which is yellow, with a black spot in the middle of the prothorax and one near the tip of each wing-cover (Fig. 244); and the margined soldier-beetle, *C. marginātus*. This species (Fig. 245) can be distinguished from the former by the head and lower parts of the femora being orange. The beetles of this genus are remarkable for having an extensible, fleshy filament attached to each maxilla. These filaments are probably used in collecting pollen and nectar from flowers.

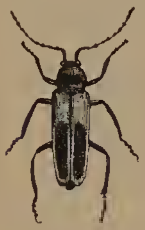

FIG. 244.

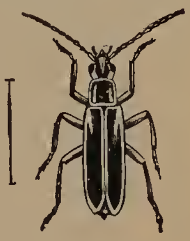

FIG. 245.

This family is represented in our fauna by nine genera which include more than one hundred and fifty species.

Family Meloidæ

The Blister-Beetles

The blister-beetles are of medium or large size. The body is comparatively soft; the head is broad, vertical, and abruptly narrowed into a neck; the prothorax is narrower than the wing-covers, which are soft and flexible; the legs are long and slender; the hind tarsi are four-jointed, and the fore and middle tarsi are five-jointed.

These beetles are found on foliage and on flowers, on which they feed in the adult state; some of the species are very common on goldenrod in the autumn; and several species feed on the leaves of potato.

The blister-beetles are so called because they are used for making blister-plasters. The beetles are killed, dried, and pulverized, and the powder thus obtained is made into a paste, which when applied to the skin produces a blister. The species most commonly used is a European one, commonly known as the Spanish-fly; but our American species possess the same blistering property.

The transformations of blister-beetles are remarkable; not only do these insects undergo wonderful changes in form, but the number of these changes is greater than is usual with insects. On this account their mode of development is termed *hypermetamorphosis*.

The beetles lay their eggs in the ground. The newly hatched larva is active, running about in search of its food, which consists, in some species, of the eggs of locusts, in others of the egg and honey of some solitary bee.

In the case of those species that live in the nests of bees the larva climbs a plant, and remains near a flower till it has a chance to seize hold of a bee visiting the flower. The larva clings to the bee until she goes to her nest, then, letting go of the bee, it remains in the cell and is shut up there with the egg of the bee and the store of food which the bee provides for her young. The beetle larva then devours the egg; after which it moults and undergoes a change of form, becoming a clumsy creature, which feeds upon the honey. Several other changes in form occur before the beetle reaches the adult stage.

The wonderful instinct by which the larvæ of these blister-beetles find their way to the nests of solitary bees has not yet reached perfection; for many of the larvæ attach themselves to flies, wasps, honey-bees, and other flower-visiting insects, and merely gain useless transportation thereby.

The life cycle of the striped blister-beetle, *Epicauta vittāta*, illustrates the hypermetamorphosis through which the blister-beetles pass. The female deposits her eggs in a mass of a hundred or more in a hole in the soil. They hatch into very active larvæ each of which is known as a *triungulin.* The triungulin has long legs and runs about in search of eggs of grasshoppers. It feeds ravenously on the eggs and in about eight days molts to the second stage, called the *caraboid* stage, because it then resembles the larva of a carabid beetle. In another week it molts and assumes the appearance of a scarabæid larva and is therefore called the *scarabœidoid* stage of the second larva. In a short time it molts again to the ultimate stage of the second larva. In about ten days more it molts again and becomes the pseudo-pupa or the *coarctate* larva. This form usually hibernates and in the spring transforms to the third larval stage. In a few days this larva transforms to the pupa in an earthen cell and in five or six days the pupa transforms to the adult beetle (Fig. 246).

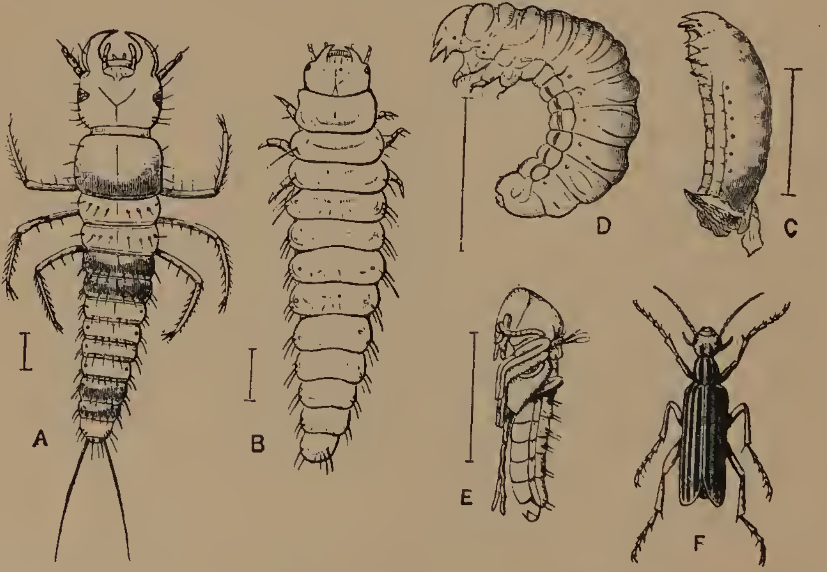

FIG. 246. — Hypermetamorphosis of the striped blister-beetle; A, triungulin; B, caraboid stage; D, scarabaeidoid stage; C, coarctate larva; E, pupa; F, adult beetle.

More than two hundred species of blister-beetles have been found in this country. Our most common species in the East belong to the genus *Epicauta*. These insects feed in the adult state on the leaves of various plants, but especially those of potato, and upon the pollen of goldenrod; the larvæ, so far as is known, are parasitic in the egg-pods of locusts. In addition to *Epicauta vittāta*, discussed above, our more common species are the Pennsylvania blister-beetle, *Epicauta pennsylvănica*, which is of a uniform black color (Fig. 247); and *Epicauta cinērea*, which is sometimes clothed throughout with an ash-colored pubescence, and sometimes the wing-covers are black, except a narrow gray margin; the two varieties were formerly considered distinct species; the first is commonly known as the gray blister-beetle, the last as the margined blister-beetle.

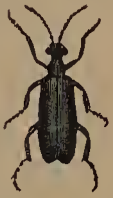
FIG. 247.

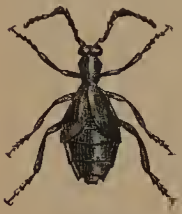
FIG. 248.

The beetles of the genus *Melœ* present an exception to the characters of the Coleoptera in that the wing-covers, instead of meeting in a straight line down the back, overlap at the base (Fig. 248). These wing-covers are short, and the hind wings are lacking. These beetles are called *oil-beetles* in England, on account of the yellowish liquid which oozes from their joints when they are handled. Our most common species is the buttercup oil-beetle, *Mĕlœ angusticŏllis*. It is found in meadows and pastures feeding on the leaves of various species of buttercups.

Family ELATERIDÆ

The Click-beetles or Elaters

There is hardly a country child that has not been entertained by the acrobatic performances of the long, tidy-appearing beetles called snapping-bugs, click-beetles, or skip-jacks (Fig. 249). Touch one of them and it at once curls up its legs, and drops as if shot; it usually lands on its back, and lies there for a time as if dead. Suddenly there is a click, and the insect pops up into the air several inches. If it comes down on its back, it tries again and again until it succeeds in striking on its feet, and then it runs off.

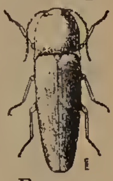
FIG. 249.

Our common species of click-beetles are mostly small or of medium size, ranging from $\frac{1}{16}$ to $\frac{3}{4}$ of an inch in length. A few species are larger, some reaching the length of nearly 2 inches. The majority of the species are of a uniform brownish color; some are black or grayish, and some are conspicuously spotted (Fig. 250). The body is elongated, somewhat flattened, and tapers more or less toward each end; the antennæ are moderately elongated and more or less serrate; the first and second abdominal segments are not grown together on the ventral side; and the hind coxæ are each furnished with a groove for the reception of the femur.

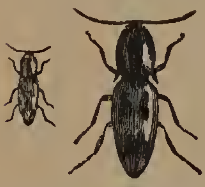
FIG. 250. — A click-beetle, *Aeolus dorsalis*, natural size and enlarged.

Adult elaters are found on leaves and flowers, and are exclusively phytophagous; the larvæ live in various situations; most of them are phytophagous, but some species are carnivorous.

The larvæ are long, narrow, worm-like creatures, very even in width, with a very hard cuticula, and are brownish or yellowish in color (Fig. 251). They are commonly known as wireworms, a name suggested by the form and hardness of the body.

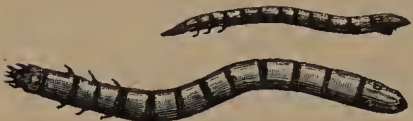

Fig. 251.

Some wireworms live under the bark of trees and in rotten wood; but many of them live in the ground, and feed on seeds and the roots of grass and grain. In fact there is hardly a cultivated plant that they do not infest, and, working as they do beneath the surface of the ground, it is extremely difficult to destroy them. They are very apt to attack the plants at the most susceptible period of their growth, before they have attained sufficient size and strength to withstand the attack; and often seed is destroyed before it is germinated.

There is a vast number of species of click-beetles; more than five hundred have been described from North America alone. It is quite difficult to separate the closely allied species, as there is but little variation in shape and color.

The corn wireworm beetle, *Melanōtus commūnis*, is a graceful brown beetle about ½ an inch in length (Fig. 249). The larva, or wireworm is about 1¼ inches in length, cylindrical and shining brown. The life cycle extends over a period of five years in most cases.

The wheat wireworm beetle, *Agriōtes măncus*, is a small brown beetle about ⅓ of an inch in length. The larva, or wireworm is about one inch long and as large as the lead in a pencil. The life cycle extends over a period of three years.

The eyed elater, *Alaus oculātus*. — Although most of our click-beetles are of moderate size, we have a few species that are large. The most common of these is the eyed elater. This is the great pepper-and-salt-colored beetle that has two large, black, velvety, eye-like spots on the prothorax (Fig. 252). These are not its eyes, however. The true eyes are situated one on each side of the head near the base of the antenna. This insect varies greatly in size, some individuals being not more than half as large as others. The larger larvæ are about two and a half inches long, and nearly two-fifths of an inch wide across the middle of the body. They are carnivorous and are often found in the trunks of old apple-trees.

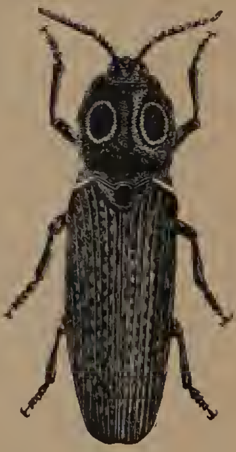

Fig. 252.

Family Buprestidæ

The Metallic Wood-borers or Buprestids

The buprestids resemble the click-beetles somewhat in form, being rather long and narrow; but they are easily recognized by their metallic coloring. Their bodies are hard and inflexible, and usually appear as if made of bronze; but some species exhibit the brightest of metallic colors. The antennæ are serrate; the first and second abdominal segments are grown together on the ventral side; and these beetles do not have the power of springing when placed on the back.

The adults are found upon flowers and upon the bark of trees, basking in the hot sunshine. Some of them fly very rapidly, with a loud buzzing noise; and some drop to the ground when disturbed, and feign death.

Most of the larvæ are borers, feeding beneath bark or within solid wood. In such species the body is of a very characteristic form, which is commonly designated as "flat-headed." The flattened portion, however, is composed largely of the segments immediately following the head. The first thoracic segment is very wide and flat; the next two or three segments are also flattened, but are successively smaller; while the rest of the body is quite narrow and cylindrical. These "flat-headed" larvæ are legless, and have been compared to tadpoles on account of their form. Their burrows are flattened, corresponding with the shape of the larger part of the body. In some of the smaller species the larvæ are cylindrical, and are furnished with three pairs of legs. These are leaf-miners; and in the adult state the body is much shorter than in the more typical species.

This family is represented in our fauna by nearly three hundred species; among the more important of those that infest cultivated plants are the following.

The Virginian buprestid, *Chalcŏphora virgĭnica.* — This is the largest of our common buprestids (Fig. 253). It is copper-colored, often almost black, and has its upper surface roughened by irregular, lengthwise furrows. This beetle appears late in spring in the vicinity of pine-trees. The larvæ bore in the wood of pine, and are often very injurious.

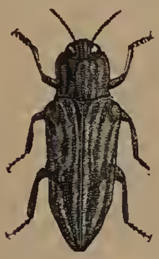
Fig. 253.

Dicĕrca divaricāta is $\frac{3}{4}$ of an inch or more in length, copper-colored or brassy above, with the wing-covers marked with square, elevated, black spots. The wing-covers taper very much behind, and are separated at the tips (Fig. 254). The larva bores in peach, cherry, beech, and maple.

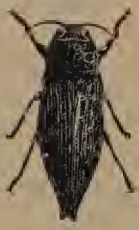
Fig. 254.

The flat-headed apple-tree borer, *Chrysobŏthris femorāta.* — This is one of the most injurious of all buprestids. The adult (Fig. 255) is about $\frac{1}{2}$ an inch long, and is very dark green above, with bronze reflections, especially in the furrows of the wing-covers. It appears during June and July, and lays its eggs upon the trunk and limbs of apple, peach, oak, and other trees. The larvæ at first bore into the bark and sap-wood, and later into the solid wood. The transformations are completed in one year.

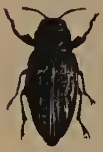
Fig. 255.

The red-necked agrilus, *Agrilus ruficŏllis.* — This beetle is about $\frac{1}{4}$ of an inch long (Fig. 256). Its body is narrow and nearly cylindrical. The head is of a dark bronze color, the prothorax of a beautiful coppery bronze, and the wing-covers black. The larva bores in the stems of raspberry and blackberry, causing a large swelling, known as the raspberry gouty-gall. These galls should be collected and burned in early spring.

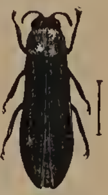
Fig. 256.

The bronze birch-borer, *Agrilus anxius*, is a greenish-bronze beetle about $\frac{1}{2}$ of an inch long which appears in June and July and deposits its egg in cracks of the bark of the white birch and of other birches. The whitish, slender larvæ bore through the sapwood and inner bark completely girdling the branches and trunk and usually killing the trees.

Family Dermestidæ

The Dermestids

There are several families of small beetles that feed on decaying matter, or on skins, furs, and dried animal substances. The most important of these is the Dermestidæ, as several species belonging to this family destroy household stores or goods.

The dermestids can be distinguished from most of the other beetles with similar habits by the fact that the wing-covers completely cover the abdomen. They are chiefly small beetles, although one of the common species measures $\frac{1}{3}$ of an inch in length. They are usually oval, plump beetles, with pale gray or brown markings, which are formed of minute scales, which can be rubbed off. These beetles have the habit of pretending that they are dead when they are disturbed; they will roll over on their backs with their legs meekly folded and lie still for a long period.

The larvæ do much more damage than the adults. They are active, and are clothed with long hairs. These hairs are covered throughout their entire length with microscopic barbs.

This family is represented in our fauna by about one hundred thirty species; the following are some of the more important to these.

The larder-beetle, *Dermĕstes lardārius.* — This pest of the larder is the most common of the larger members of this family. It measures about $\frac{1}{4}$ of an inch in length, and is black except the basal half of its wing-covers, which are pale buff or brownish-yellow. This lighter portion is usually crossed by a band of black spots, three on each wing-cover (Fig. 257). The larva feeds on dead animal matter, as meat, skins, feathers, and cheese. It is often a serious pest where bacon or ham is stored. When full-grown it is about $\frac{1}{2}$ an inch in length, dark brown above, whitish below, and rather thickly covered with long, brown hairs. It is said that these insects can be attracted by baits of old cheese, from which they may be gathered and destroyed.

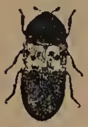
FIG. 257.

The carpet-beetle, *Anthrēnus scrophulāriæ.* — This is a well-known household pest. It is an introduced European insect, which was first recognized as a serious pest in this country about 1874. It feeds in its larval state on carpets, woollens, furs, and feathers; and for a considerable period was exceedingly destructive. The larva is well known to many housekeepers as the buffalo-moth. It is a short, fat grub, about $\frac{1}{5}$ of an inch in length when full-grown, and densely clothed with dark brown hairs. It lives in the cracks of floors, near the edges of rooms, and beneath furniture, where it eats holes in the carpet. It also enters wardrobes and destroys clothing. The adult is a pretty little beetle which may be found in infested houses, in the spring, on the ceilings and windows. It measures from $\frac{1}{12}$ to $\frac{1}{7}$ of an inch in length and is clothed with black, white, and brick-red scales. There is a whitish spot on each side of the prothorax, and three irregular, whitish spots on the outer margin of each wing-cover; along the suture where the two wing-covers meet there is a band of brick-red scales, which is widened in several places. It is worth while to learn to know this beetle; for a lady-bug which often winters in our houses is frequently mistaken for it.

The carpet-beetle in its adult state feeds on the pollen of flowers. Sometimes it abounds on the blossoms of currant, cherry, and other fruits.

The museum pests, *Anthrēnus verbăsci* and *Anthrēnus museōrum.* — There are two minute species of this family that are a constant source of annoyance to those having collections of insects. The adult beetles measure from $\frac{1}{12}$ to $\frac{1}{8}$ of an inch in length, and are very convex. They deposit their eggs on specimens in our collections; and the larvæ feed upon the specimens, often destroying them. In order to preserve a collection of insects it is necessary that they should be kept in tight cases, so that these pests cannot gain access to them. Specimens should not be left exposed except when in use. And the entire collection should be carefully examined at least once a month. The injury is done by the larvæ, which are small, plump, hairy grubs. Their presence is indicated by a fine dust that falls on to the bottom of the case from the infested specimens. These larvæ can be destroyed by pouring a small quantity of carbon bisulphide into the case, and keeping it tightly closed for a day or two. Benzine poured on a bit of cotton in the box will cause the pests to leave the specimens, when they may be taken from the box and destroyed. But we have found carbon bisulphide the better agent for the destruction of these pests.

Family TENEBRIONIDÆ

The Darkling Beetles

The darkling beetles are nearly all of a uniform black color, although some are gray, and a few are marked with bright colors. The different species vary greatly in size and in the form of the body. The hind tarsi are four-jointed, and the fore and middle tarsi are five-jointed.

These insects occur chiefly in dry and warm regions. Thus while we have comparatively few species in the northeastern United States, there are many in the Southwest. Most of the species feed on dry vegetable matter, and often on that which is partially decomposed; some live in dung, some in dead animal matter, others in fungi, and a few prey upon larvæ. More than eleven hundred species occur in this country. The three following will serve to illustrate the variations in form and habits.

The meal-worm, *Tenĕbrio mŏlitor.* — This is a well-known pest in granaries and mills. The larva is a hard waxy yellow, cylindrical "worm," which measures when full-grown 1 inch or more in length, and closely resembles a wireworm; it feeds on flour and meal. The beetle is black and about $\frac{3}{5}$ of an inch in length, (Fig. 258). The larvæ and pupæ are used for bird-food and are grown in quantity by bird-supply houses.

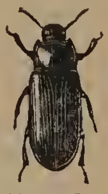
FIG. 258.

The forked fungus-beetle, *Bolitothērus cornūtus*, is common in the northeastern United States and in Canada about the large toadstools which grow on the sides of trees. The surface of the body and wing-covers is very rough, and the prothorax bears two prominent horns (Fig. 259). The larva lives within the fungi referred to above.

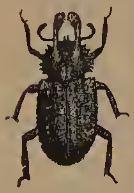
FIG. 259.

The pinacate-bugs. — Several species of *Eleōdes* are abundant on the

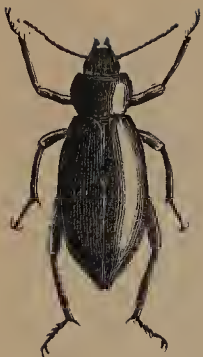

FIG. 260.

Pacific Coast, where they are found under stones and pieces of wood lying on the ground. They are apt to congregate in large numbers under a single shelter, and are clumsy in their movements. They defend themselves when disturbed by elevating the hinder part of the body and discharging an oily fluid from it. They present an absurd appearance, walking off clumsily, and carrying the hind end of the body as high as possible. The most common species are large, smooth, club-shaped beetles (Fig. 260), and are commonly known as *pinacate-bugs*. These beetles and those belonging to several closely allied genera lack hind wings.

Family CUCUJIDÆ

The Cucujids

The insects of this family are very flat and usually of an elongate form; most of the species are brown, but some are of a bright red color. As a rule they are found under bark and are believed to be carnivorous both in the larval and adult states; but some feed in grain. There are nearly one hundred species in our fauna.

The most important member of this family is the corn silvanus, *Oryzæphilus surinamĕnsis*, which is one of the small beetles that infest stored grain. This species is readily distinguished from other small beetles with similar habits by its flattened form and the saw-like edges of the prothorax. Besides grain it often infests dried fruits and other stores. It measures from $\frac{1}{10}$ to $\frac{1}{8}$ of an inch in length. The larva as well as the adult feeds on grain. It differs from the larva of the granary-weevil (*Sitophilus*) in the more elongate form of its body and in the possession of three pairs of legs.

Family COCCINELLIDÆ

The Lady-bugs

These insects are well-known to nearly everyone under the popular name given above. They are more or less nearly hemispherical, generally red or yellow, with black spots, or black, with white, red, or yellow spots.

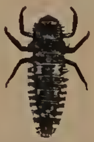

FIG. 261.

The larvæ occur running about on foliage; they are often spotted with bright colors and clothed with warts or with spines (Fig. 261). When ready to change to a pupa the larva fastens itself by its tail to any convenient object, and the skin splits open on the back. Sometimes the pupa state is passed within this split skin, and sometimes the skin is forced back and remains in a little wad about the tail (Fig. 262).

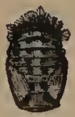

FIG. 262.

With very few exceptions, the lady-bugs are predacious, both in the larval and adult states. They feed upon small insects and upon the eggs of larger species. The larvæ of certain species are known as " niggers " by hop-growers, and are greatly prized by them; for they are very destructive to the hop-louse. On the Pacific Coast lady-bugs are well-known as the most beneficial of all insects to the fruit-growers. In addition to the native species found there, several species have been introduced as a means of combating scale-insects. One of these, *Rodōlia cardinālis*, has provėd of very great value in subduing the cottony-cushion scale (*Icerya purchasi*). This lady-bug was introduced from Australia.

A very common one is the two-spotted lady-bug, *Adālia bipunctāta*. This species is reddish-yellow above, with the middle of the prothorax black, and with a black spot on each wing-cover. It frequently passes the winter in our dwellings, and is found on the walls and windows in early spring. Under such circumstances it is often mistaken for the carpet-beetle, and, unfortunately, destroyed. (See Plate I, Figure 3).

The nine-spotted lady-bug, *Coccinĕlla novemnotāta*, has yellowish wing-covers, with four black spots on each, in addition to a common spot just back of the scutellum (Fig. 263).

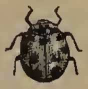

Fig. 263.

There are two " black sheep " in this family of lady-bugs, namely, the squash lady-bug, *Epilăchna boreālis* and the bean lady-bug, *Epilăchna corrŭpta*. The adults and larvæ of both of these species are herbivorous and injurious, especially those of the latter. The bean lady-bug from its former home in the south-western states, suddenly appeared in Alabama in 1919 and has now spread over most of the eastern United States and into Canada. It is pale yellowish to orange-brown and from $\frac{1}{4}$ to $\frac{1}{3}$ of an inch in length. Each wing-cover has eight black spots arranged in three transverse rows. The larvæ and adults feed on bean plants and are very destructive.

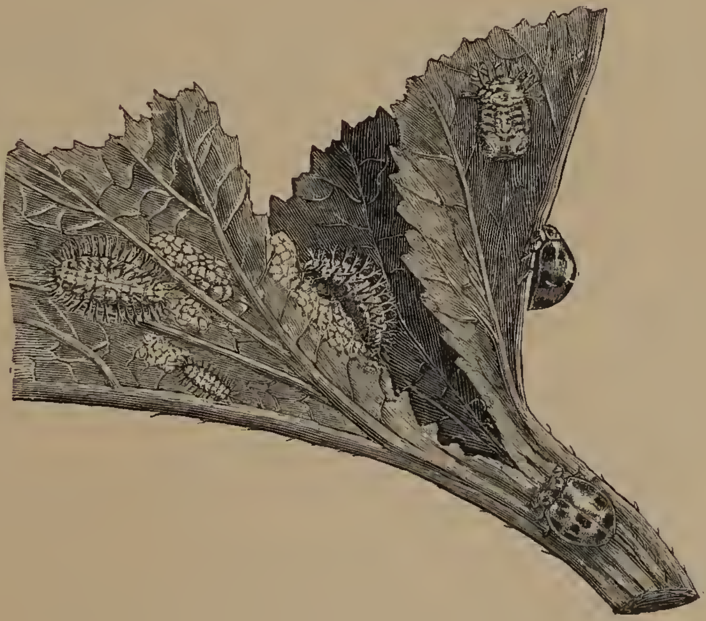

Fig. 264.

The squash lady-bug lives on various cucurbitaceous plants but it prefers the squash and often becomes destructive (Fig. 264).

Family SCARABÆIDÆ

The Scarabæids or Lamellicorn Beetles

This very large family is represented in our fauna by nearly one thousand species, and includes beetles that exhibit a wide range of variation in size, form, and habits. They are mostly short, stout-bodied beetles, of which the well-known June-bugs or May-beetles represent the most familiar type. The most useful character for distinguishing these insects is the lamellate form of the club of the antennæ, the segments constituting it being greatly flattened, and capable of being brought close together. It is this character that suggests the name lamellicorn beetles.

According to their habits, the members of this family can be separated into two well-marked groups — the scavengers and the leaf-chafers.

THE LAMELLICORN SCAVENGERS

The lamellicorn scavengers in both the larval and adult states feed upon decaying vegetable matter. Nearly all the species live in dung, chiefly that of horses and cows; but a few species feed upon fungi. The following are the more common representatives of this division.

The tumble-bugs. — These are the most familiar of all dung-beetles, for their peculiar habits have attracted much attention from the earliest times. They are of rounded form, and the wing-covers are shortened so as to expose the tip of the abdomen. They are generally black, but some are colored with rich metallic hues. They vary greatly in size.

The name *tumble-bug* refers to the habit which many species exhibit of forming round balls of dung, which they roll long distances and then bury. They often work in pairs and it was formerly believed that such a pair was a male and a female working together to make provision for their progeny; but Fabre found by dissecting the beetles that the two members of a pair often proved to belong to the same sex; and concluded that the eager fellow-worker, under the deceitful pretense of lending a helping hand, nurses the scheme of purloining the ball at the first opportunity.

According to the observations of Fabre, the balls made early in the year are devoured by the beetles, which bury themselves with them and feed upon them. Later, other balls are made and buried, upon each of which an egg is laid. The larva hatching from this egg feeds upon the ball of dung, and when full-grown transforms within the cavity in which the ball was placed.

This strange habit of rolling these balls has occasioned much speculation as to its object, and has been the source of many superstitions, especially in ancient times. The only reasonable theory that we have met is that, as many predacious insects frequent the masses of dung from which the balls are obtained, in order to prey upon the larvæ which live there, the more intelligent tumble-bugs remove the food for their larvæ to a safe distance.

The most noted member of this group of genera is the sacred beetle of the Egyptians, *Ateuchus săcer.* This insect was held in high veneration by this ancient people. It was placed by them in the tombs with their dead; its picture was painted on sarcophagi, and its image was carved in stone and precious gems. These sculptured beetles can be found in almost any collection of Egyptian antiquities.

From the habits and structure of this scarabæid the Egyptians evolved a remarkable symbolism. The ball, which the beetles were supposed to roll from sunrise to sunset, represented the earth; the beetle itself personified the sun, because of the sharp projections on its head, which extend out like rays of light; while the thirty segments of its six tarsi represented the days of the month. All individuals of this species were thought to be males, and a race of males symbolized a race of warriors. This latter superstition was carried over to Rome and the Roman soldiers wore images of the sacred beetle set in rings.

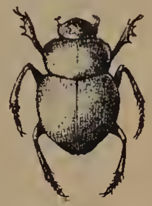
Fig. 265. — *Canthon lævis.*

Our common tumble-bugs are distributed among three genera: *Cănthon* (Fig. 265), *Cōpris*, and *Phanæus.*

THE LAMELLICORN LEAF-CHAFERS

The leaf-chafers are herbivorous insects which in the adult state usually feed upon the leaves of trees, but many of the species devour the pollen and petals of flowers. In the larval state some of these insects are found in rotten wood; others live in the ground, where they feed upon the roots of grass and other plants. These larvæ are thick, fleshy grubs, with well-developed legs (Fig. 266). The caudal segments of the abdomen are very large, and appear black on account of the large amount of dirt in the intestine. The body is strongly curved, so that the larvæ can crawl only with great difficulty; when in the ground they usually lie on their backs.

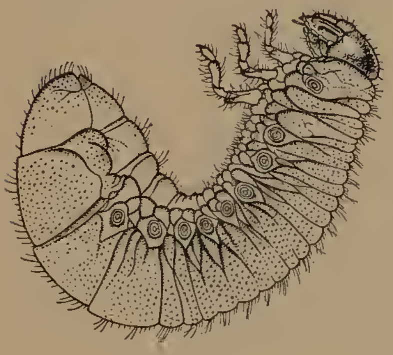
Fig. 266.

The following groups include the more important representatives of this division.

I. *The May-beetles or June-bugs.* — During the warm evenings of May and June we throw open our windows so that we may feel the refreshing coolness of the night air and the inspiration of the new summer. Suddenly, as we sit working or reading, our peace is disturbed by a buzzing object which whirls above us. Then comes a sharp thud and silence. A little later the scratching of six pairs of tiny claws tells us the whereabouts of the intruder. But so familiar are we with his kind that we need not look to know how he appears, the mahogany-brown blunderer, with yellowish wings sticking out untidily from under his polished wing-covers.

Although these insects are beetles, and attract our attention each year in May, they have received the infelicitous title of June-bugs. They are more properly termed May-beetles.

The May-beetles belong to the genus *Phyllŏphaga*, of which we have nearly one hundred species. The adults frequently do much injury by eating the foliage of trees. In the case of large trees this injury usually passes unnoticed; but small trees are often completely defoliated by them. When troublesome, they can be easily gathered by shaking them from trees upon sheets. Figure 267 represents a common species.

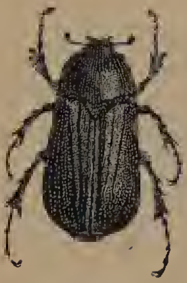

FIG. 267.

The larvæ of the different species of May-beetles are commonly classed together under the name "white grubs." They are often great pests in meadows and in cultivated fields. We have known large strawberry plantations to be destroyed by them, and have seen large patches of ground in pastures from which the dead sod could be rolled as one would roll a carpet from a floor, the roots having been all destroyed and the ground just beneath the surface finely pulverized by these larvæ. No satisfactory method of fighting this pest has been discovered as yet. If swine be turned into fields infested by white grubs they will root them up and feed upon them. We have destroyed great numbers of the beetles by the use of trap-lanterns, but many beneficial insects were destroyed at the same time.

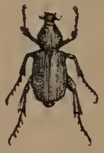

FIG. 268.

II. *The rose-bugs.* — The common rose-bug, *Macrodăctylus subspinōsus*, is a well-known pest. It is a slender beetle, tapering before and behind, and measuring ⅓ of an inch in length (Fig. 268). It is thickly clothed with fine, yellow, scale-like hairs, which give it a yellowish color; the legs are long, slender, and of a pale red color. These beetles appear in early summer and often do great injury to roses and other flowers, and to the foliage of various fruit-trees and shrubs. This is a very difficult pest to control. The larvæ of rose-bugs feed on the roots of plants.

III. *The shining leaf-chafers.* — These insects resemble the May-beetles in form, but can be distinguished from them by the position of the hind pair of spiracles, which are visible on the sides below the edges of the wing-covers; and they differ from the other leaf-chafers in which the spiracles are in this position in that the tarsal claws are of unequal size, one claw of each pair being larger than the other. These beetles are usually polished, and many of them are of brilliant colors. To this family belong the most beautiful beetles known, many appearing as if made of burnished gold or silver, or other metal.

The goldsmith-beetle, *Cotălpa lanĭgera.* — This is one of our most beautiful species. It measures about one inch in length, and is a broad oval in shape. It is of a lemon-yellow color above, glittering like burnished gold on the top of the head and thorax; the under side of the body is copper-colored and thickly covered with whitish wool.

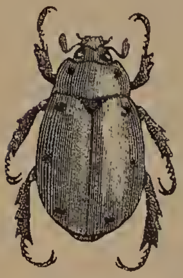

FIG. 269.

The spotted pelidnota, *Pelidnōta punctāta.* — This beetle is reddish-brown above, with three black spots on each wing-cover and one on each side of the prothorax (Fig. 269). The scutellum, base of the head, and entire body beneath, are of a deep, bronzed-green color. The adult is commonly found feeding on the leaves of grape. The larva feeds upon decaying roots and stumps of various trees.

The Japanese beetle, *Popĭllia japŏnica.* — This is a very serious pest which feeds in the adult state on the foliage of many cultivated and wild plants, being practically omnivorous, and in the larval state feeds on the roots of grasses. It was first observed in this country in a limited area in

Burlington County, New Jersey, in 1916, and has since spread into Pennsylvania and New York. The adult insect is about the size of the Colorado potato-beetle, but slightly longer (Fig. 270). The head and thorax are shining bronze-green in color, with the wing-covers tan or brownish, tinged with green on the edges. Along the sides of the abdomen are white spots, and two very distinct white spots at the tip of the abdomen below the wing-covers. The larva resembles the larvæ of May-beetles.

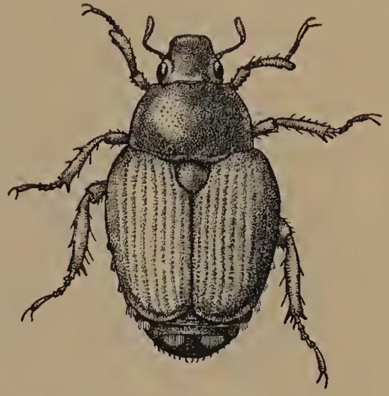
Fig. 270. — Japanese beetle, enlarged three times.

IV. *The rhinoceros-beetles.* — The name *rhinoceros-beetles* was suggested for this group by the fact that in many species the male bears a horn on the middle of the head. In addition to this horn there may be one or more horns on the thorax. These beetles are of medium or large size; in fact, the largest beetles known belong to this group. As with the flower-beetles, the claws of the tarsi are of equal size, but the fore coxæ are transverse, and not prominent.

One of the largest of our rhinoceros-beetles is *Dynăstes tĭtyrus*. This is of a greenish-gray color, with scattered black spots on the wing-covers, or, if only recently transformed, of a uniform dark brown. The male (Fig. 271) bears a prominent horn on the top of the head, and a large one and two small ones on the prothorax. The female has only a tubercle on the head. This insect is found in the Southern States; the larva lives in rotten wood. In the far west there is a closely allied species, *Dynăstes grăntii*, in which the large horn on the thorax is twice as long as in *D. tityrus*. In the West Indies there occurs a species, *Dynăstes hĕrcules*, which measures 6 inches in length.

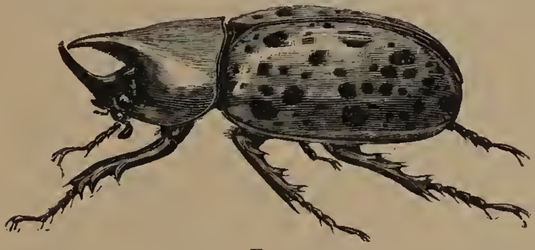
Fig. 271.

The sugar-cane beetle, *Euethēola rūgiceps*, is a serious pest in the cane-fields of Louisiana, and it sometimes injures corn (Fig. 272).

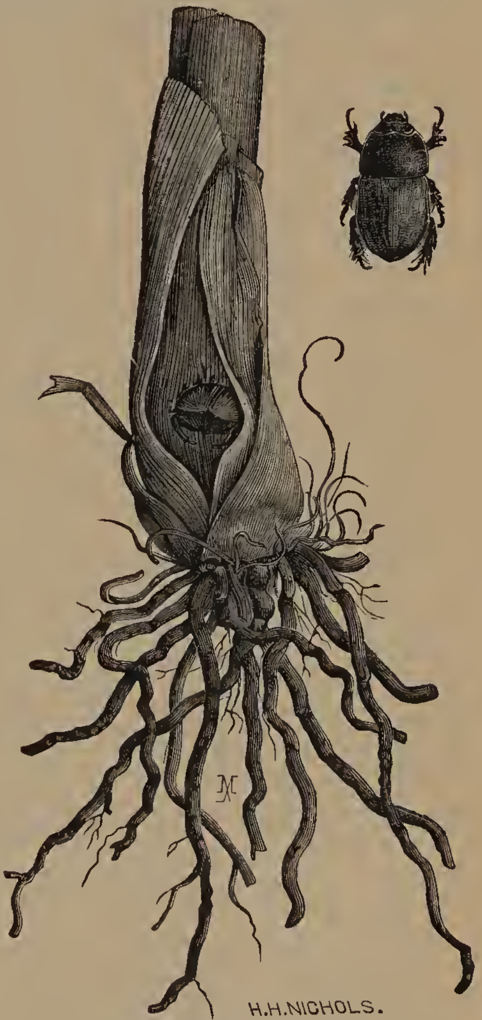

Fig. 272. — The sugar-cane beetle.

V. *The flower-beetles.* — The flower-beetles are so called because many of them are often seen feeding upon pollen and flying from flower to flower. These beetles are somewhat flattened, or nearly level on the back; the claws of the tarsi are of equal size and the fore coxæ are conical and prominent. More than one hundred species occur in this country.

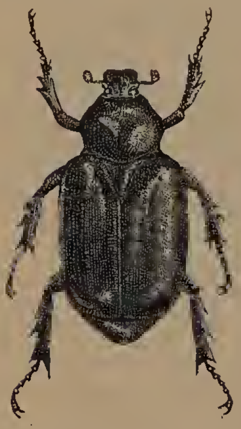

FIG. 273.

The hermit flower-beetle, *Osmodĕrma eremĭcola.* — This is one of the larger of our flower-beetles (Fig. 273). It is of a deep mahogany-brown color, nearly smooth, and highly polished. It is supposed that the larva lives on decaying wood in forest trees.

The genus *Euphōria* represents well the form of the more typical flower-beetles, which are distinguished by the margin of each wing-cover having a large, wavy indentation near its base, which renders the side pieces of the mesothorax visible from above. This indentation makes it unnecessary for these insects to raise or expand their wing-covers when flying, as most beetles do, as they are able to pass the wings out from the sides.

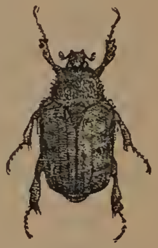

FIG. 274.

The bumble flower-beetle, *Euphōria ĭnda.* — The most common of our flower-beetles, at least in the North, is a yellowish-brown one, with the wing-covers sprinkled all over with small, irregular, black spots (Fig. 274). It is one of the first insects to appear in the spring. It flies near the surface of the ground with a loud humming sound, like that of a bumblebee, for which it is often mistaken. During the summer months it is not seen; but a new brood appears about the middle of September. The adult is a general feeder occurring upon flowers, eating the pollen, upon corn-stalks and green corn in the milk, sucking the juices, and upon peaches, grapes, and apples. Occasionally the ravages are very serious.

The green June-beetle or fig-eater, *Cŏtinus nĭtida.* — This species extends over the Atlantic slope, and is very common in the South. It is a green, velvety insect, measuring about one inch in length. It is somewhat pointed in front, and usually has the sides of the thorax and elytra brownish-yellow. These beetles often fly in great numbers at night, making a loud buzzing noise similar to that of the May-beetles. In fact, in the South the term *June-bug* is often applied to this insect. The larvæ feed upon the vegetable mold of rich soils; sometimes they injure growing vegetables by severing the roots and growing stalks; but the chief injury is due to the upheaval of the soil around the plants, which disturbs the roots; the larvæ are also often troublesome on lawns and golf greens by making little mounds of earth on the surface. Sometimes they leave the ground and crawl from one place to another. When they do so, they, strangely enough, crawl upon their backs, making no use of their short legs. On one occasion we saw them crawling over the pavements on the Capitol grounds at Washington in such numbers that bushels of them were swept up and carted away. The adults frequently attack fruit, especially figs, grapes, and peaches.

A closely related beetle, *Cotinus mutabilis*, occurs in the Southwest and attacks fruits in a similar manner. So far as known, its habits and life history are much like those of the fig-eater.

Family TROGIDÆ

The Skin-beetles

This is a small family, which is represented in this country by twenty-five species. Until recently these insects were included in the preceding family; they can be distinguished from scarabæids by the fact that the epimera of the mesothorax do not extend to the coxæ as they do in the Scarabæidæ. The members of this family are oblong, convex species, in which the surface of the body and wing-covers is usually very rough, and covered with a crust of dirt, which is removed with great difficulty. They are small or of medium size; our most common species measure from $\frac{1}{3}$ to $\frac{1}{2}$ an inch in length. The abdomen is covered by the elytra; the feet are hardly fitted for digging, but the femora of the front legs are greatly dilated.

These beetles feed upon dried, decomposing animal matter; many species are found about the refuse of tanneries, and upon the hoofs and hair of decaying animals.

Except a few species found in the far west, all of our species belong to the genus *Trox* (Fig. 275).

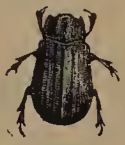

FIG. 275.

Family LUCANIDÆ

The Stag-beetles

The stag-beetles are so called on account of their large mandibles which in the males of some species are branched like the antlers of a stag. They and the members of the following family are distinguished by the form of the club of the antennæ, which is composed of flattened plates; but these plates are not capable of close apposition, as in the antennæ of the lamellicorn beetles. In the stag-beetles the mentum is not emarginate and the ligula is covered by the mentum or is at its apex.

The adult beetles are found in or beneath decaying logs and stumps. Some of them are attracted at night to lights. They are said to live on honey-dew and the exudations of the leaves and bark of trees, for procuring which the brushes of their jaws and lips seem to be designed; but it seems probable that some species, at least, feed upon decomposing wood. They lay their eggs in crevices of the bark of trees, especially near the roots. The larvæ feed upon juices of wood in various stages of decay. They resemble the well-known larvæ of May-beetles.

The family is a small one; only thirty North American species are now known.

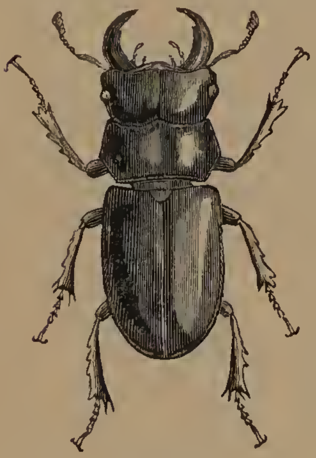

FIG. 276.

The common stag-beetle, *Lucānus dama.* — The most common of our stag-beetles is this species (Fig. 276). It flies by night with a loud buzzing sound, and is often attracted to lights in houses. The larva is a large, whitish grub resembling the larvæ of the lamellicorn beetles. It is found in the trunks and roots of old, partially decayed trees, especially apple, cherry, willow, and oak. The specimen figured here is a male; in the female the mandibles are shorter.

The giant stag-beetle, *Lucānus ĕlaphus*, is a large species found in the South. It measures from 1$\frac{2}{5}$ inches to 2 inches in length, not including the mandibles, which in the case of the male are more than half as long as the body, and branched like the antlers of a stag.

The antelope-beetle, *Dŏrcus parallēlus*. — This beetle is somewhat smaller than the species of *Lucanus*, and differs in having the wing-covers marked with longitudinal striæ and the teeth on the outside of the fore tibiæ much smaller (Fig. 277).

Several species of stag-beetles that are much smaller than *Dorcus* are found in this country.

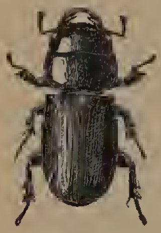
Fig. 277.

Family Passalidæ

The members of this family resemble the stag-beetles in the form of the antennæ, but differ in that the mentum is deeply emarginate, with the ligula filling the emargination.

A single, widely distributed species is found in the United States; this is the horned passalus, *Păssalus cornūtus* (Fig. 278). It is a large, shining, black beetle, with a short horn, bent forwards, on the top of the head. This beetle and its larva are found in decaying wood. The larva appears to have only four legs, the hind legs being shortened and modified so as to form part of a stridulating organ.

The beetles of this genus are common throughout the tropics of both hemispheres. According to the observations of Ohaus, which have been confirmed by Professor Wheeler, these beetles are social. They form colonies, consisting of a male and female and their progeny, and make large, rough galleries in rather damp, rotten logs. The parent beetles triturate the rotten wood and apparently treat it with some digestive secretion which makes it a proper food for the larvæ, since their mouth-parts are too feebly developed to enable them to attack the wood directly. All members of the colony are kept together by stridulatory signals. The stridulatory organ of the adult consists of patches of minute denticles on the dorsal surface of the abdomen, which may be rubbed against similar structures on the lower surface of the wings.

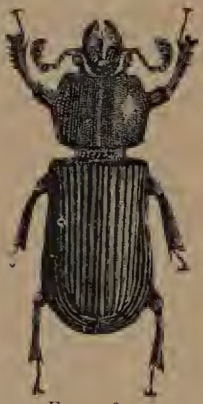
Fig. 278.

Family Cerambycidæ

The Long-horned Beetles or Cerambycids

This is a very large family, there being more than eleven hundred described species in North America alone. As a rule the beetles are of medium or large size, and graceful in form; many species are beautiful in color. The body is oblong, often cylindrical. The antennæ are long, often longer than the whole body; but except in one genus, *Prionus*, they are only eleven-jointed, as with most beetles. The legs are also long, and the tarsi are apparently four-jointed, the fourth segment being very small and hidden; the third segment of the tarsi is strongly bilobed (Fig. 279).

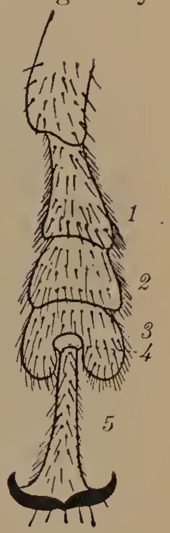

Fig. 279.

They are strong flyers and swift runners; but many of them have the habit of remaining motionless on the limbs of trees for long intervals, and when in this apparent trance they suffer themselves to be picked up. But, when once caught, many species make an indignant squeaking by rubbing the prothorax and mesothorax together.

The larvæ are borers, living within the solid parts of trees or shrubs, or beneath bark. They are white or yellowish grubs. The body is soft, and tapers slightly from head to tail (Fig. 280); the jaws are powerful, enabling these insects to bore into the hardest wood. The larval state usually lasts two or three years. The pupa state is passed within the burrow made by the larva; frequently a chamber is made by partitioning off a section of the burrow with a plug of chips; but sometimes the larva builds a ring of chips around itself just beneath the bark before changing to a pupa. The pupal state is comparatively short, lasting only a few days or weeks.

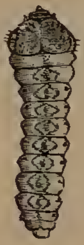

Fig. 280.

THE PRIONIDS

The larger of the long-horned beetles constitute a subfamily. They are distinguished from other cerambycids by having the sides of the prothorax prolonged outwards into a thin margin, which is more or less toothed. The wing-covers are usually leathery in appearance, and of a brownish or black color. The following are our best-known species.

The broad-necked prionus, *Priōnus laticŏllis*. — This is the largest of our common species; but the individuals vary from 1 to 2 inches in length. It is of a pitchy-black color, and of the form shown in Figure 281. The antennæ are twelve-jointed in both sexes. The larva is a large, fleshy grub, and infests the roots of grape, apple, poplar, and other trees.

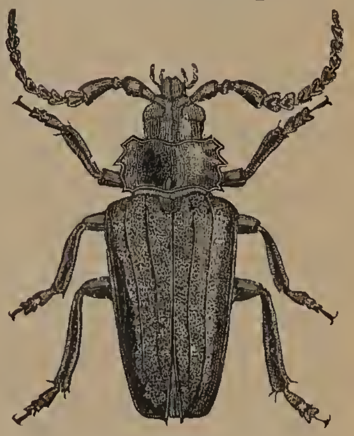

Fig. 281.

The tile-horned prionus, *Priōnus imbricŏrnis*, is very similar to the preceding species but can be distinguished at a glance by the form of the antennæ. In the antennæ of the male the number of segments varies from eighteen to twenty, while in the female the number varies from sixteen to seventeen. The popular name refers to the fact that the segments of the antennæ of the male overlap one another like the tiles on a roof. The larva infests the roots of grape and pear, and also feeds upon the roots of herbaceous plants. A closely related species, *Prionus californicus*, occurs on the Pacific Coast. The larva is from 2½ to 3 inches long.

THE TYPICAL CERAMBYCIDS

In this group the prothorax is rounded on the sides, the tibiæ of the fore legs are not grooved, and the palpi are never acute at the tip. There are nearly four hundred American species, representing more than one hundred genera. The few species mentioned below are those that the beginning student is most likely to meet.

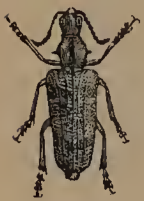
Fig. 282.

The ribbed pine-borer, *Rhāgium lineātum.* — This is a gray beetle mottled with black, and has a narrow thorax, with a spine on each side (Fig. 282). It received its name because of the three ridges extending lengthwise on each wing-cover. Its larva bores in the wood of pine-trees. On one occasion the writer found many of them in a pine-tree eight inches in diameter, which they had bored through and through. When the larva is full-grown it makes a hole nearly through the thick bark of the tree, so that it may easily push its way out after its transformations; it then retreats a short distance and makes a little ring of chips around itself, between the bark and the wood, and changes to a pupa within this rude cocoon. The adult beetle remains in this pupal cell through the winter.

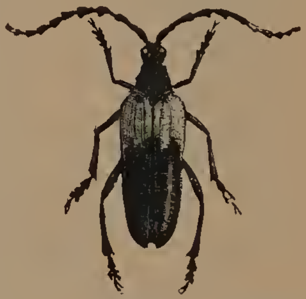
Fig. 283. — *Desmocerus palliatus.*

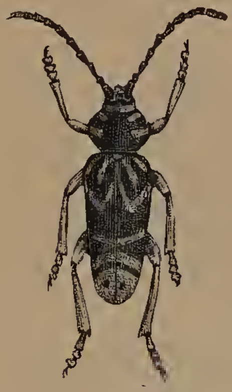
Fig. 284.

The cloaked knotty-horn, *Desmŏcerus palliātus.* — This beautiful insect is of a dark blue color, with greenish reflections. The basal part of the wing-covers is orange-yellow, giving the insect the appearance of having a yellow cape thrown over its shoulders (Fig. 283). The segments in the middle of the antennæ are thickened at the outer end, so that they look like a series of knots. The adult is quite common in June and July on elder, in the pith of which the larva bores.

The beautiful maple-borer, *Glycōbius speciōsus.* — This is a handsome insect, marked with black and yellow, as indicated in Figure 284. It lays its eggs in midsummer on the trunks of sugar-maples, in the wood of which the larvæ bore. If an infested tree be examined in the spring the presence of these borers can be detected by the dust that falls from the burrows. The larvæ can be destroyed at this time by the use of a knife and a stiff wire.

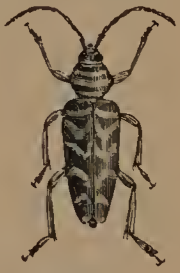
Fig. 285.

The locust-borer, *Cyllēne robĭniæ.* — To the enthusiastic entomologist the goldenrod is a rich mine, yielding to the collector more treasures than any other flower. It gives up its gold-dust pollen to every insect-seeker; and because of this generous attitude to all comers it is truly emblematic of the country that has chosen it as its national flower.

Among the insects that revel in this golden mine in the autumn is a black beetle with numerous transverse or wavy yellow bands (Fig. 285). This beetle is also found on locust-trees, where it lays its eggs. The larvæ bore under the bark and into the hard wood.

The locust-trees have been completely destroyed in some localities by the depredations of these larvæ.

The painted hickory-borer, *Cyllēne cāryæ.* — This beetle resembles the preceding so closely that the same figure will represent either. But the hickory-borer not only infests a different kind of tree, but appears in the spring instead of the autumn. In this species the second segment of the hind tarsus is densely pubescent beneath, while it is glabrous in the locust-borer.

THE LAMIIDS

As in the preceding group, the prothorax is rounded with these beetles; but the lamiids are distinguished by having the fore tibiæ obliquely grooved on the inner side, and the last segment of the palpi cylindrical and pointed. The following are some of the more important species.

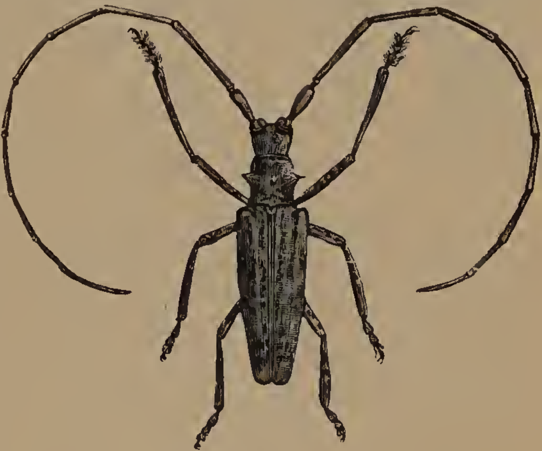

Fig. 286.

The sawyer, *Monŏchamus notātus.* — This beautiful brownish-gray beetle is about 1⅕ inches long, with antennæ as long as the body in the case of the female and twice as long in the case of the male (Fig. 286). The larva bores in the sound wood of pine and of fir, making, when full-grown, a hole ½ inch in diameter. The pupal state is passed within the burrow. It sometimes occurs in such numbers as to kill the infested trees.

The round-headed apple-tree borer, *Sapĕrda căndida.* — Excepting the codling-moth, which infests the fruit, this is the worst enemy of the apple that we have. Its common name is used to distinguish it from the flat-headed apple-tree borer, already described, the larva of this species being nearly cylindrical in form (Fig. 280). The eggs are laid on the bark of the trunk of the tree late in June or July. The larva at first bores in the soft sap-wood, making a disk-shaped mine; after this it works in an upward direction in the harder wood, and at the close of its larval existence comes to the surface several inches above the place it entered. It requires nearly three years for this larva to attain its growth; it changes to a pupa, near the upper end of its burrow, about the middle of May, and emerges as a beetle in June. The beetle (Fig. 287) is of a pale brown color above, with two broad white stripes extending the whole length of the body. Although the larva is found chiefly in apple, it infests many other trees. The presence of the borers can be detected by the sawdust-like castings which the larvæ throw out at the entrances of their burrows.

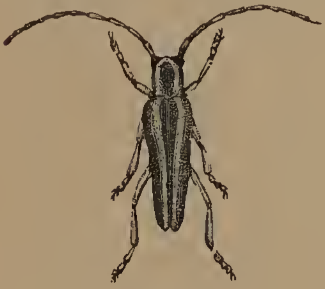

Fig. 287.

The two-spotted oberea, *Obĕrea bimaculāta*, is sometimes a serious pest, boring in the canes of blackberry and raspberry. The larva resembles that of the preceding species. The adult (Fig. 288) is about ½ of an inch in length and of a deep black color, except the prothorax, which is yellow. There are usually two or three black spots on the pronotum, but frequently these are wanting.

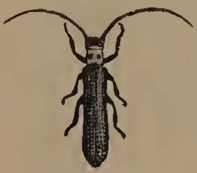
FIG. 288.

The red milkweed-beetles, *Tetraŏpes*. — There are several species of bright red beetles that are common on milkweeds (*Asclepias*). These belong to the genus *Tetraopes*. Our most common species (Fig. 289) is *T. tetraophthălmus*. In this species there are four black spots on each wing-cover, and the antennæ are black and not ringed with a lighter color. The larva bores in the roots and the lower parts of the stems of milkweeds.

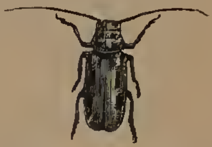
FIG. 289.

Family CHRYSOMELIDÆ

The Leaf-beetles or Chrysomelids

The leaf-beetles are so called because they feed upon the leaves of plants both as larvæ and adults. They are usually short-bodied, and more or less oval in outline; the antennæ are usually of moderate length; and the front is not prolonged into a beak. The legs are usually short, and are furnished with tarsi of the same type as those of the preceding family (see Fig. 279, p. 161).

Although we are unable to cite any characteristic that will invariably distinguish these beetles from the preceding family, the student will rarely have any difficulty in making the distinction. The beetles of the genus *Donācia*, described below, are the only common ones that are liable to be misplaced. In other cases the more or less oval form of the body, and the comparatively short antennæ, and the leaf-feeding habits, will serve to distinguish the chrysomelids.

The leaf-beetles are nearly all comparatively small, the Colorado potato-beetle being one of our larger species.

The eggs are usually elongated and yellowish, and are laid upon the leaves or stems of the plants upon which the larvæ feed. Many of the larvæ live exposed on the leaves of plants; others that live in similar situations cover themselves with their excrement; some are leaf-miners; and a few, as the striped squash-beetle, bore in the roots or stems of plants.

This is a large family, of which nearly one thousand North American species are known. The following illustrations will serve to show the variations in form and habits.

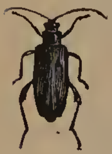
FIG. 290.

The long-horned leaf-beetles, *Donācia*. — These are the common leaf-beetles that are liable to be mistaken for cerambycids. They are of elongated form, with slender antennæ (Fig. 290). They measure from ¼ to ½ inch in length, and are of a metallic color — either greenish, bronze, or purplish. The lower side of the body is paler and is clothed with very fine hair which serves as a water-proof coat when the insect is submerged. The larvæ feed upon the roots or in the stems of aquatic plants; and the adults are found on the leaves of the same plants. We have many species, but they resemble one another so closely that it is difficult to separate them.

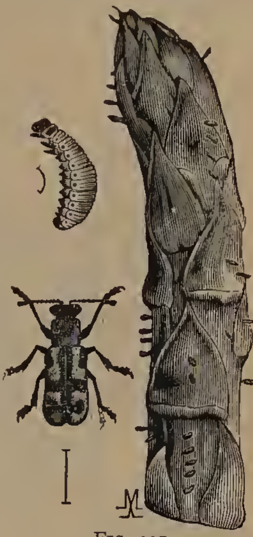

FIG. 291.

The asparagus-beetle, *Criŏceris aspăragi.* — This is a small red, yellow, and black beetle, that gnaws holes in the heads of young asparagus, and lays oval, black eggs upon them. The larvæ, which are small, brown, slug-like grubs, also feed upon the young heads in the spring, and later in the season a second brood feed upon the full-grown plant. Figure 291 represents a head of asparagus bearing the eggs of this beetle, also a beetle and a larva enlarged. The beetle measures about ¼ of an inch in length.

The grape rootworm, *Fĭdia lŏngipes.* — This insect is the most destructive enemy of the grape occurring east of the Rocky Mountains. The adult is a small grayish-brown beetle, measuring about ¼ of an inch in length. It feeds on the leaves in July, eating out characteristic chain-like holes. The eggs are laid beneath the loose bark of the vines. On hatching, the larvæ drop to the ground and burrow down to the roots, which they destroy, causing the death of the vine. Most of the larvæ do not transform till the following spring.

The Colorado potato-beetle, *Leptinotărsa decemlineāta.* — A good many insect tramps have come to us from Europe and from the Orient, and appropriated whatever pleased them of our growing crops or stored grain. But two of our worst insect pests have swarmed out on us in hordes from their strongholds in the region of the Rocky Mountains. These are the Rocky Mountain locust and the Colorado potato-beetle (Fig. 292). The latter insect dwelt near the base of the Rocky Mountains, feeding upon the sand-burr (*Solanum rostratum*), until about the year 1859. At that time it began to be a pest in the potato-fields of the settlers in that region. Having acquired the habit of feeding upon the cultivated potato, it began its eastward march across the continent, spreading from potato patch to potato patch. At first the migration took place at about the rate of fifty miles a year, but later it was more rapid; and in 1874 the insect reached the Atlantic Coast.

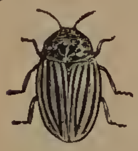

FIG. 292.

The adult beetles hibernate in the ground; they emerge early in April or May, and lay their eggs on the young potato plants as soon as they appear; both larvæ and adult beetles feed on the foliage of the potato. The larvæ enter the ground to transform. This pest is usually controlled by the use of Paris green.

The diabroticas. Several very important pests belong to the genus *Diabrŏtica*. They are chiefly greenish-yellow beetles, marked with black stripes or spots. The striped diabrotica, *D. vittāta*, has two black stripes on each wing-cover. The adult feeds on the leaves of cucumber, squash, and melon; and the larva, which is a slender, worm-like creature, bores in the stems and roots of the same plants. The twelve-spotted diabrotica, *D. duodecimpunctāta*, and *Diabrŏtica sōror*, agree in having six black spots on each wing-cover. The former is very common in the East; the latter occurs on the Pacific Coast, and is the most destructive of all of the diabroticas. *Diabrŏtica longicŏrnis* is a green species, which feeds on the pollen and silk of corn and on the pollen of other plants. Its larva is known as the corn rootworm; it is very destructive to corn in the Mississippi Valley. Its injuries are greatest where corn is grown on the same land year after year; hence a rotation of crops should be practised where this pest is troublesome.

The fleabeetles. — There is a group of leaf-beetles, of which we have many species, in which the hind legs are fitted for leaping, the thighs being very large. These are commonly called the fleabeetles.

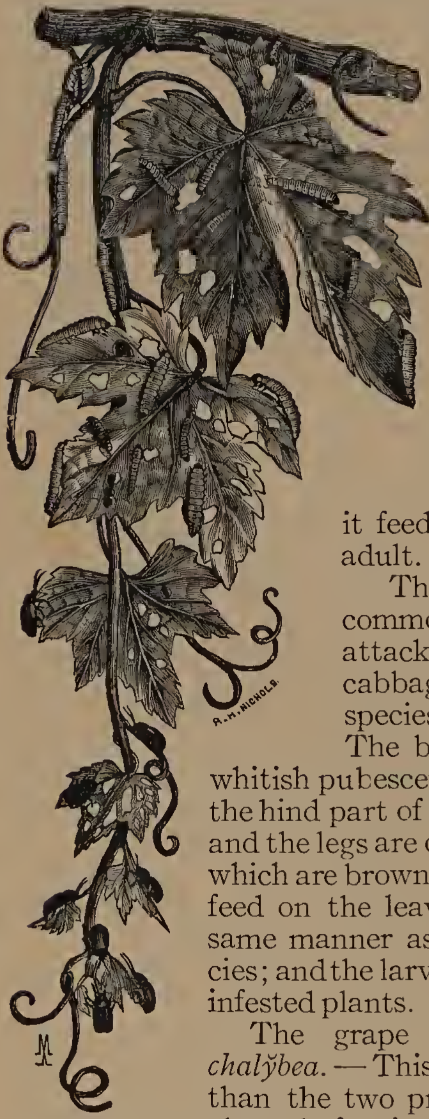

FIG. 294.

The striped fleabeetle, *Phyllotrēta vittāta*, is exceedingly common on cabbage, turnip, radish, mustard, and allied plants. It is a small, black, shining beetle, with a broad, wavy, pale, dull yellow stripe upon each wing-cover (Fig. 293); it measures about $\frac{1}{10}$ of an inch in length. These beetles eat numerous little pits in the thicker leaves that they infest, and minute perforations in the thinner-leaved plants. The larva is a slender, white worm, about $\frac{1}{3}$ of an inch in length; it feeds on the roots of the plants infested by the adult.

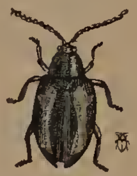

FIG. 293.

The cucumber fleabeetle, *Epitrix cucŭmeris*, is a common pest of melon and cucumber vines; it also attacks the leaves of potatoes, raspberry, turnip, cabbage, and other plants. This is a minute black species, measuring less than $\frac{1}{12}$ of an inch in length. The body is finely punctured and clothed with a whitish pubescence; there is a deep transverse furrow across the hind part of the prothorax; the antennæ are dull yellow, and the legs are of the same hue, except the posterior femora, which are brown. The adult beetles feed on the leaves of plants in the same manner as the preceding species; and the larvæ on the roots of the infested plants.

The grape fleabeetle, *Hăltica chalȳbea.* — This is a larger species than the two preceding, measuring about $\frac{1}{5}$ of an inch in length, and is of a dark, steel-blue color. It is a great pest in vineyards, eating into the buds of grape in early spring, and later gnawing holes in the leaves (Fig. 294). In May and June the brown, sluggish larvæ may also be found feeding upon the surface of the leaves. The full-grown larva is chestnut brown marked with black spots (Fig. 295). It drops to the ground and makes a cell in the earth in which it transforms. The most important injury caused by this pest is the destruction of buds in early spring, which causes a great loss of foliage and fruit.

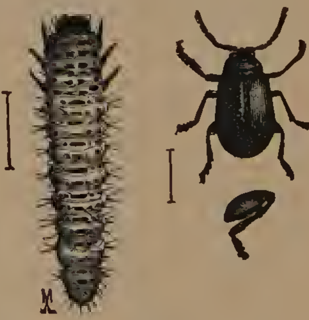

FIG. 295.

The wedge-shaped leaf-beetles. — These insects are characterized by the peculiar form of the body, which is narrow in front and broad behind. In most of the species the body is much roughened by deep pits, and usually the pits on the wing-covers are in regular rows. These insects and the tortoise-beetles differ from other leaf-beetles in having the fore part of the head prominent, so that the mouth is confined to the under surface. Some of the larvæ feed externally upon the leaves and bear a parasol composed of their excrement; other species are leaf-miners. *Baliōsus rubra* is a good representative of this group (Fig. 296). It varies in length from $\frac{1}{8}$ to $\frac{1}{5}$ of an inch. It is of a reddish color, with the elevated portions of the elytra more or less spotted with black. The larva mines in the leaves of apple, forming a blotch-mine; the transformations are undergone within the mine. We have also found this species mining the leaves of basswood in great numbers.

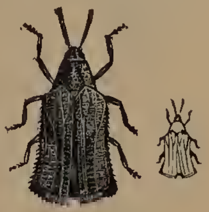
FIG. 296.

The tortoise-beetles. — Among the more beautiful Coleoptera are certain bright golden, green, or iridescent beetles found on the leaves of sweet potato, morning-glory, nettle, and other plants. In these beetles the body is flattened below and convex above; the head is nearly or quite concealed beneath the prothorax; and the margins of the prothorax and elytra are broadly expanded, forming an approximately circular or oval outline, and suggesting a resemblance to the shell of a tortoise (Fig. 297). Not all of the species are iridescent; and in the case of those that are, the brightness of the colors is said to depend on the emotions of the insect. What a beautiful way to express one's feelings — to be able to glow like melted gold when one is happy! Unfortunately for the beauty of our collections, these bright colors disappear after the death of the insect.

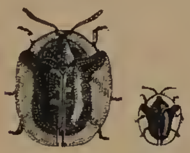
FIG. 297.

The larvæ of the tortoise-beetles are flattened, and have the margin of the body fringed with spines. At the caudal end of the body there is a forked appendage which serves a very strange purpose. This fork is bent forward over the back, and to it are attached the cast-off skins of the larva and its excrement; these constitute a parasol. When about to change to the pupa state these larvæ fasten the caudal end of the body to the underside of a leaf; the skin then splits open, and is forced back to this end of the body, where it remains.

The black-legged tortoise-beetle, *Cassida nigripes*, is a beautiful golden species which lives on the vines of the sweet potato. It is a little over $\frac{1}{4}$ of an inch in length and each wing-cover bears three black spots arranged in a triangle. The beetle loses its brilliant tone if disturbed and when it dies the golden color fades to a yellowish-brown.

Family MYLABRIDÆ

The Pea-weevil Family

These are small beetles, the larvæ of which live in the seeds of leguminous plants. The head of the adult is prolonged into a broad beak; and the wing-covers are rather short, so that the tip of the abdomen is always exposed (Fig. 298). This is a comparatively small family; ninety-three species are listed in our fauna, of which eighty-one belong to the genus *Mylabris*.

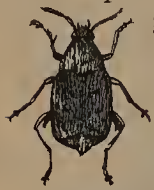

Fig. 298.

The pea-weevil, *Mȳlabris pisōrum.* — "Buggy peas" are well known in most sections of our country; but just how the "bugs" find their way into the peas is not so generally understood. The eggs of the pea-weevil are laid upon the pod while the peas are quite small; when the larvæ hatch they bore through the pod into the young peas. Here they feed upon the substance of the seed, which ripens, however, and in some cases will germinate when planted. The larva before transforming eats a circular hole on one side of the seed, leaving only a thin scale, which is easily pushed away by the mature beetle. The adult is about $\frac{1}{5}$ of an inch in length; it is dark brown, with a few white spots on the wing-covers, and one on the prothorax near the middle. Sometimes the beetles leave the peas during the autumn or winter; but as a rule they remain in the seed till spring, and are often planted with it. Seed peas should be placed in water, and the infested ones, which will float, should be picked out and destroyed. This species is not known to oviposit on dry peas.

The bean-weevil, *Mȳlabris obtĕctus.* — This species resembles the preceding quite closely; but it is a little smaller (Fig. 298), and lacks the white markings characteristic of *M. pisorum*. It infests beans, and often several individuals inhabit a single bean. The eggs are laid within the pod, being pushed through a slit which the female gnaws through the pod. This species will oviposit on dry beans, peas, and other grain, and will continue to breed for many generations in stored beans and peas.

The Snout-Beetles

The Group Rhynchophora[*]

The five families included in this series constitute a well-marked division of the order, which has long been known as the Rhynchophora or snout-beetles. These names were suggested by the fact that in many of these insects the head is prolonged so as to form a snout or beak; but it should be remembered that, while these names are very appropriate for a large part of this series, in some members of it the head is not thus prolonged. This is especially true of the last two families, the bark-beetles and timber-beetles, in which the beak is either wanting or extremely short and broad.

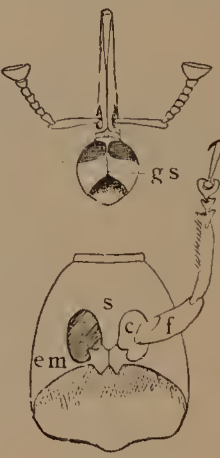

Fig. 299.

The most distinctive features characterizing this series of families are the following: the suppression of the gula, the gular sutures being confluent (Fig. 299, *gs*); the absence of sutures between the prosternum and the episterna and epimera; the meeting of the epimera of the prothorax on the middle line behind the prosternum (Fig. 299, *em*); and the palpi being usually short and rigid.

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[*] Rhynchŏphora: *rhynchos* (New Latin), snout; *phoros* (φόρος), bearing.

Family Brentidæ

The Primitive Weevils

This family is confined chiefly to tropical regions; only six species are found in the United States, and but one of these in the North.

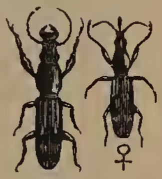

Fig. 300.

The northern brentid, *Eŭpsalis minūta.* — In the female the head is prolonged into a slender snout; but in the male the snout is broad and flat, and is armed with a pair of powerful jaws (Fig. 300). These are weapons of offence, for the males fight desperately for their mates; and too, the males are generally larger than the females. In these respects these insects resemble the stag-beetles, the males of which also fight for their mates.

The northern brentid is found beneath the bark of recently felled or dying oak, poplar, and beech trees in the solid wood of which the larvæ bore; and is widely distributed over the United States and Canada.

Family Platystomidæ

The Fungus Weevils

This family includes a small number of snout-beetles in which the beak is short and broad, and the labrum is present; the antennæ are not elbowed, and the terminal segments rarely form a compact club; the palpi are flexible; and the prothorax bears a transverse elevated ridge at or near its base.

The larvæ of many species infest woody fungi, others breed in the smut of corn and wheat, and still others bore in dead wood. The larvæ of one cosmopolitan species, known as the coffee-bean weevil, *Aræŏcerus fasciculātus*, attack seeds of various plants.

Sixty-two species of this family are known to occur in America north of Mexico. This family is the Anthribidæ of many authors.

Family Curculionidæ

The Curculios or Typical Snout-beetles

The Curculionidæ is a very large family; it is represented in America north of Mexico by more than eighteen hundred species; to it belong four-fifths of all our Rhynchophora. This family includes the typical snout-beetles, the head being prolonged into a well-defined beak, which is usually long and curved downward.

The following are some of the more important members of this family.

The sweet potato weevil, *Cȳlas formicārius*, is an Asiatic species which has invaded the Gulf states. The beetle is somewhat ant-like in form, a fact which suggested its specific name. It is about $\frac{1}{4}$ of an inch in length. The elytra, head, and snout are bluish-black while the prothorax is reddish-brown. Both larvæ and adults bore into the stems and tubers of the sweet potato and sometimes do very serious damage.

The imbricated snout-beetle, *Epicærus imbricātus*, is usually a dull, silvery white beetle with brown markings; but the species is quite variable in color. It is represented, somewhat enlarged, in Figure 301. It is omnivorous, gnawing holes in various garden vegetables, strawberry plants, and other fruits. The greater part of the insect is clothed with imbricated scales, which suggested the specific name.

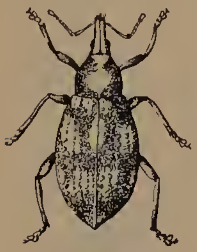
FIG. 301.

The New York weevil, *Ithўcerus noveboracĕnsis*. This is a large species, measuring from ½ to ¾ of an inch in length. It is black, rather sparsely clothed with a mixture of ash-gray and pale brown prostrate hairs which give it a black-spotted appearance. The beak is short and broad. The mandibles are prominent, not very stout, and emarginate at the tip, with an inferior cusp. The antennæ are not elbowed; the first segment is longer than the second; and the terminal segments form a small, oval club.

This species breeds in the twigs and tender branches of oak, hickory, and possibly other forest trees. The adult beetles appear in early spring, and sometimes do much damage to fruit-trees by eating into buds, and gnawing the tender bark on new growth. They can be caught by jarring them on to sheets or by the use of a plum-curculio catcher. (This weevil is placed in a separate family, *Belidæ*, by some authors.)

The strawberry crown-girdler, *Brachyrhīnus ovātus*. — This is a dark brown, almost black, snout-beetle, about ⅕ of an inch in length, which often invades dwellings in search of shelter, in the Northern States and Canada. The larvæ feed on the roots of the strawberry, cutting them off near the crown. The adults feed on the foliage. In the adult, the hind wings are wanting and the elytra are grown together.

The black vine-weevil, *Brachyrhīnus sulcātus*. — This beetle is larger than the preceding species, measuring ⅓ of an inch in length; it is black, with small patches of yellowish hairs on the elytra. The larvæ destroy the roots of strawberries; and both larvæ and adults infest various greenhouse plants.

The plum-curculio, *Conotrachēlus nĕnuphar*. — This is the insect that stings plums, often destroying a large portion of the fruit; the larva is also the well-known "worm" of "wormy" cherries. This species is the most destructive insect that infests plums, cherries, and other stone fruits; it also breeds in apple. Its presence in an orchard can be determined early in the season by a peculiar mark it makes when laying its eggs in the young fruit. The female beetle makes an incision, with her snout, through the skin of the fruit. In this incision she lays a single egg, which she pushes with her snout to the bottom of the cavity that she has prepared. She then makes a crescent-shaped incision in front of the one containing the egg. This last cut undermines the egg, leaving it in a little flap. The larvæ feed within the fruit. In the case of the plums the infested fruit falls to the ground; but not so with cherries. When full-grown the larvæ go into the ground to transform. This species infests nectarines, apricots, and peaches, as well as plums and cherries.

The strawberry-weevil, *Anthŏnomus signātus*, infests strawberry, blackberry, raspberry, and dewberry. The female beetle, after laying an egg in the flower-bud, causes it to fall by cutting the pedicel; the larva develops within the fallen bud.

The cotton-boll weevil, *Anthŏnomus grăndis*, is one of the most serious insect pests known in the United States. It infests only cotton. The egg is deposited in a young boll, which the larva destroys. The adults (Fig. 302) also feed upon the young bolls and upon the leaves. This species is a native of Central America. It spread through Mexico, and entered Texas about 1890. Since that time it has spread over a large part of the cotton belt. Very extensive investigations of this pest have been made by the Federal Government and by several state governments; and much literature regarding it is available to those interested.

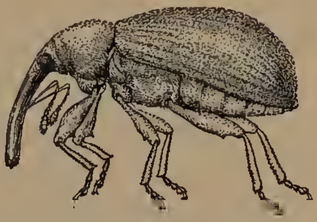
Fig. 302. — The Mexican cotton-boll weevil, much enlarged.

The acorn-weevil, *Balăninus rĕctus*, has a slender snout twice as long as the body (Fig. 303). The female drills a hole in the young acorn with this snout and then lays an egg in the opening afterwards pushing it to the bottom of the hole with her snout. The grub devours the interior of the acorn.

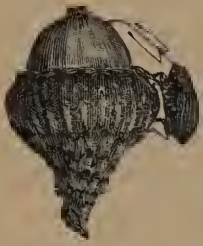
Fig. 303.

The hickory-nut weevil, *Balăninus năsicus*, breeds in hickory nuts and the chestnut weevil, *Balăninus proboscĭdeus*, causes wormy chestnuts. Each of these weevils have a long slender snout, longer than the body.

Among the smaller members of this family are two exceedingly important pests of stored grains; these are the granary-weevil, *Calăndra granāria*, and the rice-weevil, *Calăndra orȳzæ.* The rice-weevil is so called because it was first found in rice in India; but it infests various kinds of stored grain; and in the South it is fully as important a granary-pest as is the granary-weevil.

The two species are quite similar in appearance; but the granary-weevil is the larger, measuring from $\frac{1}{8}$ to $\frac{1}{6}$ of an inch in length; while the rice-weevil measures less than $\frac{1}{8}$ of an inch in length, and differs from the granary-weevil in having the elytra marked with four reddish spots. The thorax of the rice-weevil is closely pitted with round punctures; that of the granary-weevil, with sparse elongate punctures.

The adult female of both of these species gnaws a tiny hole in a kernel of grain and then deposits an egg in it. The larva feeds on the grain, becomes full-grown, and transforms within the kernel. The adult continues the injury begun by the larva, eating out the inside of the kernel.

Family PLATYPODIDÆ

This is a small family, which is represented in our fauna by a single genus, *Plătypus*, of which only five species have been found in America north of Mexico; these are found chiefly in the South and the far West.

Formerly this group was classed as a subfamily of the Scolytidæ. It is distinguished from the Scolytidæ by the fact that the first segment of the anterior tarsi is longer than the second, third, and fourth together. The form of the body is cylindrical (Fig. 304); and the head is large, wider than the prothorax.

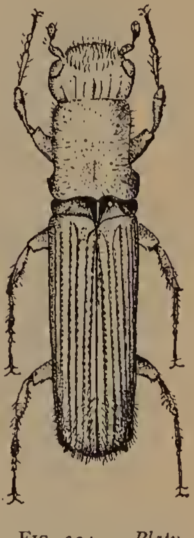
Fig. 304. — *Platypus wilsoni*, female. (After Swaine.)

The species of this genus attack many kinds of conifers and deciduous trees. They bore deeply into the heart-wood, making "pin-holes" that often render lumber useless. The eggs are deposited in the galleries; and the larvæ feed on a fungus, which is cultivated by the beetles and is known as ambrosia. In this respect *Platypus* resembles several genera of the Scolytidæ, which also bore in solid wood and feed on ambrosia; all of these are known as ambrosia-beetles. The galleries of ambrosia-beetles are usually blackened by the fungus. See further account of the ambrosia-beetles in the discussion of the next family.

Family SCOLYTIDÆ

The Engraver-beetles and the Ambrosia-beetles

The members of the family Scolytidæ are mostly of cylindrical form (Fig. 307) and of small or moderate size; some species measure only $\frac{1}{25}$ of an inch in length, but others are much larger, attaining a length of $\frac{1}{4}$ of an inch or more. They are usually brown, sometimes black, and with many the hind end of the body is very blunt, as if cut off. The antennæ are elbowed or bent in the middle, and are clubbed at the tip; the tibiæ are usually serrate; and the first segment of the anterior tarsi is shorter than the second, third, and fourth together.

A few members of this family infest herbaceous plants; our most important one of these is the following.

The clover-root borer, *Hylăstinus obscūrus.* — This pest was introduced from Europe and has become the most serious enemy of clover, especially red clover and mammoth clover, in New York State and in other sections of the North. It bores in the roots of plants beginning their second year of growth and destroys them (Fig. 305). Where it is common it is practically impossible to keep fields in clover longer than the second summer after seeding. In these regions it is the common practice to seed with clover and timothy mixed; after the clover disappears the field becomes a timothy meadow. No practical method of control of this pest has been found.

Most scolytid beetles infest woody plants; among them are some of the most destructive enemies of forest-trees, and a few attack fruit-trees. As a rule they are more liable to attack sickly trees, but their injuries are not confined to these.

The scolytid beetles exhibit two radically different types of habits; and from this point of view they can be grouped into two groups: first the engraver-beetles or bark-beetles; and second, the ambrosia-beetles or timber-beetles. These two

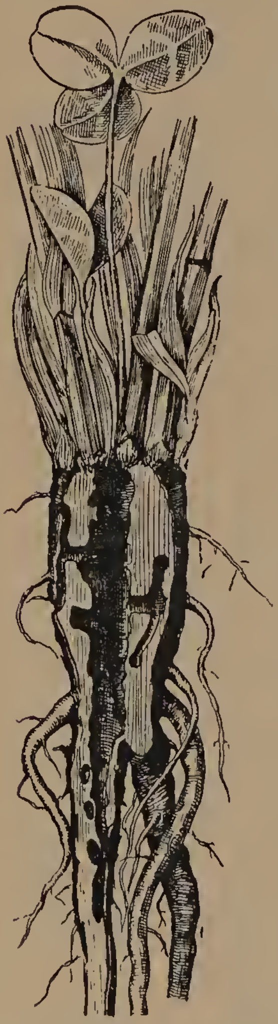

FIG. 305. — Work of clover-root borer. (After Webster.)

groups, however, do not represent a natural division of the family based on structural characters. The peculiar habits of the ambrosia-beetles are believed to have arisen independently in different parts of the series of scolytid beetles.

The Engraver-beetles or Bark-beetles

If the bark be pulled from dead branches or trunks of trees, the inner layer and the sap-wood will be found, in many cases, to be ornamented with burrows of more or less regular form. The smoothly cut figures are the mines of engraver-beetles, which are also known as bark-beetles. Many kinds of these engravings can be found, each characteristic of a particular species of engraver-beetles. A common pattern is shown in Figure 306.

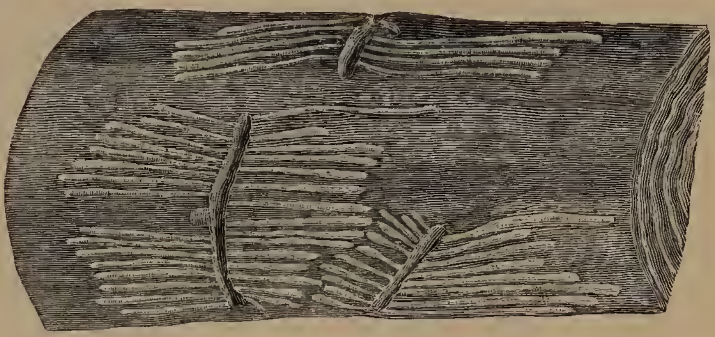

Fig. 306.

The different species of engraver-beetles vary so greatly in the details of their habits that it is difficult to make generalizations regarding them in the space available here. In a common type, the adult beetle, after penetrating the bark, makes a tunnel in the inner layer of the bark or in the sap-wood or in both; this is known as the egg-tunnel, and may be either simple or branched. In the sides of the tunnel, most species make niches, the egg-niches, in which the eggs are laid. The larva when hatched feeds on the bark or sap-wood or both and thus makes a lateral tunnel. These lateral tunnels made by the larvæ often extend parallel in a more or less regular manner.

While most of the engraver-beetles infest forest-trees, the two following species are well-known pests of fruit-trees.

The fruit-tree bark-beetle, *Eccoptogăster rugulōsus.* — This species infests apple, quince, plum, peach, and other stone-fruits. It is sometimes called the shot-hole borer by fruit-growers on account of the small entrance holes of its burrows. The adult beetle measures from $\frac{1}{12}$ to $\frac{1}{10}$ of an inch in length, and is dark brown or nearly black. It infests chiefly sickly trees.

The peach-tree bark-beetle, *Phthorophlœus liminăris.* — This species resembles the preceding in size and habits, except that its injuries are confined chiefly to peach and cherry. It can be distinguished from the fruit-tree bark-beetle by the fact that the club of the antennæ is lamellate, an unusual feature in this family (Fig. 307).

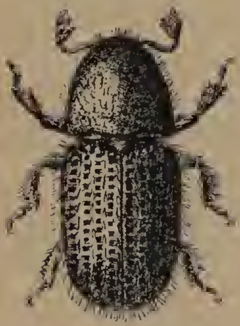

Fig. 307. — *Phthorophlœus liminaris.*

The Ambrosia-beetles or Timber-beetles

Certain members of the family Scolytidæ differ in habits from the engraver-beetles or bark-beetles in a remarkable manner; these are those known as ambrosia-beetles or timber-beetles. They are termed *ambrosia-*

beetles because they cultivate fungi, commonly called ambrosia, upon which they feed; and *timber-beetles*, because they burrow in the solid wood.

The galleries of the ambrosia-beetles can be distinguished from those of other wood-boring insects by the fact that in all of their ramifications they are of uniform size and free from wood-dust and other refuse, and their walls are stained black or brown by the fungus that is grown upon them.

The galleries of different species differ in form; but usually there is a main gallery, which extends deeply into the solid wood and is often branched; and extending from the sides of the main gallery there are short chambers, termed cradles, in each of which an egg is laid and a larva reared (Fig. 308). In some species, the female deposits her eggs loosely in the galleries, and the young and old live together in the same quarters.

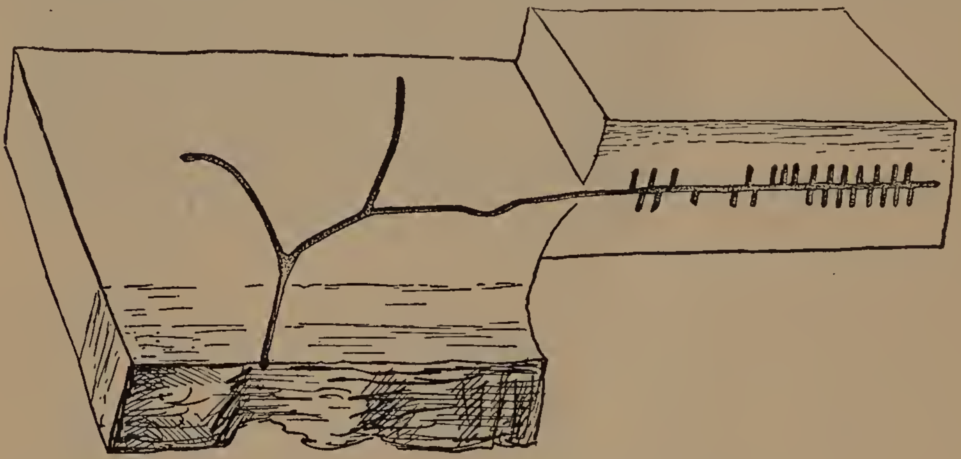

Fig. 308. — Gallery of *Monarthrum mali* in maple. (From Hubbard.)

The galleries are excavated by the adult beetles. In some species the gallery is started by a single female, in others the males assist the females in this work. The entrances through the bark to the galleries are similar to those made by the bark-beetles and like them are known as "shot-holes." Under favorable conditions colonies may continue their excavations during two or three generations.

The fungi upon which these beetles feed are carefully cultivated by them. So far as is known, each species of ambrosia-beetle cultivates only a single species of fungus, and only the most closely allied species have the same food-fungus. The fungus is started by the mother-beetle upon a carefully packed bed or layer of chips. It is probable that some conidia are brought for this purpose from the gallery in which the female was developed. The excrement of the larvæ is used in some and probably in all the species to form new beds for the propagation of the fungus.

In those species in which the larvæ are reared in separate cradles, "the mother-beetle is constantly in attendance upon her young during the period of their development, and guards them with jealous care. The mouth of each cradle is closed with a plug of the food-fungus, and as fast as this is consumed it is renewed with fresh material. The larvæ from time to time perforate this plug and clean out their cells, pushing out the pellets of excrement through the opening. This debris is promptly removed by the mother and the opening again sealed with ambrosia. The young transform to perfect beetles before leaving their cradles."

While the ambrosia-beetles are chiefly injurious to forest-trees, there are certain species that injure wine and beer casks; and one species, the pear-blight beetle, *Anisăndrus pyri*, sometimes infests the tips of pear and apple branches, causing an injury that is often mistaken for the bacterial disease known as pear-blight.

Nearly four hundred species of scolytid beetles, representing many genera, have been described from America north of Mexico.

FAMILIES OF COLEOPTERA NOT DISCUSSED

The order Coleoptera includes a great number of families the members of which are rare or little known. The special student of the beetles is referred to "An Introduction to Entomology" by J. H. Comstock and to special treatises on the Coleoptera for an account of the families which we have not been able to discuss in this Manual.

Omophronidæ
Haliplidæ
Amphizoidæ
Rhysodidæ
Clavigeridæ
Pselaphidæ
Histeridæ
Sphæritidæ
Scaphidiidæ
Platypsyllidæ
Leptinidæ
Scydmænidæ
Clambidæ
Brathinidæ
Corylophidæ
Trichopterygidæ
Sphæriidæ
Psephenidæ
Dryopidæ
Elmidæ
Ptinidæ
Anobiidæ
Bostrichidæ
Lyctidæ
Nosodendridæ
Byrrhidæ
Chelonariidæ
Cupesidæ
Dascillidæ
Eucinetidæ
Helodidæ
Nitidulidæ
Rhizophagidæ
Ostomidæ
Eucnemidæ
Cerophytidæ
Throscidæ
Phalacridæ
Mycetophagidæ
Cryptophagidæ
Erotylidæ
Rhipiceridæ
Derodontidæ
Cleridæ
Corynetidæ
Melyridæ
Lymexylidæ
Cebrionidæ
Plastoceridæ
Phengodidæ
Lycidæ
Micromalthidæ
Endomychidæ
Lathridiidæ
Monotomidæ
Heteroceridæ
Colydiidæ
Murmidiidæ
Mycetæidæ
Cisidæ
Georyssidæ
Lagriidæ
Othniidæ
Sphindidæ
Eurystethidæ
Alleculidæ
Monommidæ
Melandryidæ
Pythidæ
Œdemeridæ
Cephaloidæ
Pedilidæ
Anthicidæ
Euglenidæ
Pyrochroidæ
Rhipiphoridæ
Mordellidæ

CHAPTER XXI

ORDER STREPSIPTERA *

The Stylopids or Twisted-winged Insects

The members of this order are small, endoparasitic insects, which prey on other insects. Only the males are winged; in this sex, the fore wings are reduced to club-shaped appendages; the hind wings are large compared with the size of the tiny body, fan-shaped, furnished with radiating wing-veins, and folded longitudinally when at rest. The adult female is larviform and legless. The mouth-parts are vestigial or wanting; the alimentation is probably by osmosis. Both sexes undergo a hypermetamorphosis.

The order Strepsiptera comprises insects that were formerly classed as a family of the Coleoptera, the Stylopidæ; for this reason, these insects have been known as the stylopids. Recently since the establishment of the order Strepsiptera, the name *the twisted-winged insects*, derived from the technical name of the order, has been proposed for them; but the old name is less cumbersome, and will probably continue to be used.

The stylopids are small insects which live parasitically within the bodies of other insects, chiefly bees, wasps, digger wasps, and certain Homoptera. Their small size and the fact that nearly their entire existence is passed within the bodies of their hosts result in their being rarely seen except by those who are searching for them. During the first stadium the young larvæ of both sexes are free, and the adult winged male leads a free existence for a brief period.

The stylopids are most easily found by examining adult individuals of the species of insects that they infest, in which may be found adult females and male pupæ of the parasites. The presence of a stylopid is indicated by the projecting of the head end of the body from between two of the abdominal segments of the host (Fig. 309). Frequently a single host will contain several parasites.

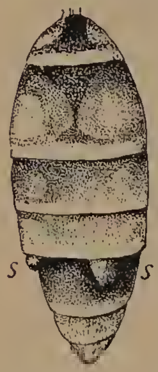

Fig. 309. — Abdomen of stylopized insect: *s*, stylopids.

Figure 310 will serve to illustrate the appearance of an adult male stylopid. The more striking features are the flabellate antennæ; the large, stalked. compound eyes; the shortness of the prothorax and the mesothorax, and the great length of the metathorax; the reduction of the fore wings to club-shaped appendages; and the large size of the hind wings.

The antennæ of adult males differ greatly in form in the different families of this order. The number of antennal segments varies from four to seven.

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* Strepsĭptera: *strepsis* (στρέψις), a turning; *pteron* (πτερόν), a wing.

The mouth-parts of the males are greatly reduced and the mouth opening is small. The labrum and labium are wanting as distinct parts.

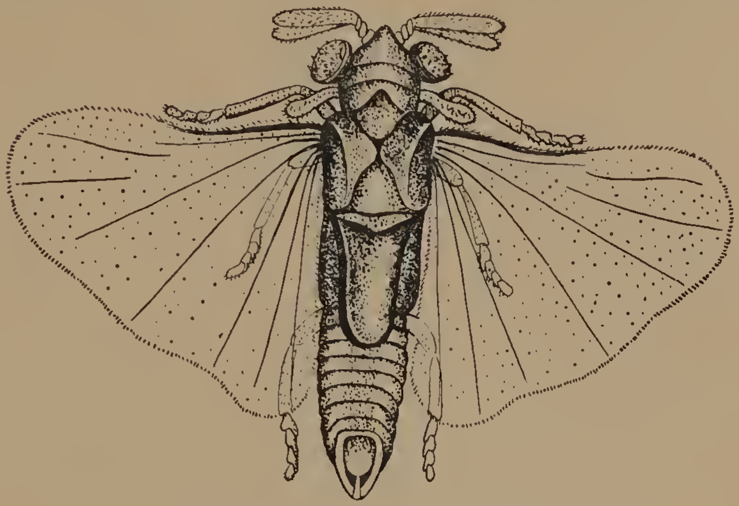

FIG. 310. — A male stylopid. (After Pierce.)

In some species the mandibles are slender, curved and scimitar-like while the maxillæ are two-segmented. In others the mandibles are greatly reduced.

The three pairs of legs are similar in form and the abdomen is composed of ten segments.

The adult female is very degenerate in form. That part of the body which projects from the body of the host is the cephalothorax, the head and thorax being consolidated into a single disk-like region. The abdomen, which is within the body of the host, is a great sac filled with eggs. The body of the adult female is inclosed in the skin of the last larval instar, which is termed the puparium; but there is no pupal stage in this sex.

Owing to their parasitic life the development and life-cycles of these insects are very complex and remarkable. The young larva is very active for it must hunt around and find a host insect. Many of these larvæ, of course, never find a host and therefore starve. This contingency is provided for, however, because a female stylopid has been known to produce as many as 2000 young. After the young stylopid finds a host it bores to the inside of the body and begins its parasitic life. The larvæ pass through several molts and assume different forms in their progress toward maturity, the females after the early stages differing in their development from the males. The female remains larval-like in form even when full-grown.

The order, Strepsiptera, is well represented in this country, ninety-seven species having been listed and probably there are many undiscovered species.

CHAPTER XXII

ORDER MECOPTERA *

The Scorpion-flies and Their Allies

The winged members of this order have four wings; these are usually long, narrow, membranous, and furnished with a considerable number of cross-veins; the wings are wanting or vestigial in two genera. The head is prolonged into a deflexed beak, at the end of which chewing mouth-parts are situated. The metamorphosis is complete.

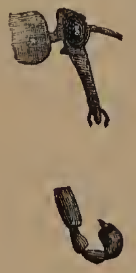

FIG. 311. — Head and tail of *Panorpa*.

This is a small order composed of very remarkable insects. The most striking character common to all is the shape of the head, which is prolonged into a deflexed beak (Fig. 311). The beak is formed from the greatly elongated clypeus, submentum, and stipes of the maxillæ with the rather small, slender mandibles situated at the tip.

The antennæ are long, very slender, and many-segmented. The compound eyes are moderately large and the legs are long and slender with five-segmented tarsi.

The wings are membranous and are usually long and narrow but in certain rare forms they are comparatively broad. The venation of the wings is generalized but with many cross-veins.

The metamorphosis is complete. The larvæ are caterpillar-like, with three pairs of thoracic legs and with or without abdominal prolegs. The pupæ are exarate, that is, the wings and legs are free, as in the Coleoptera and Hymenoptera.

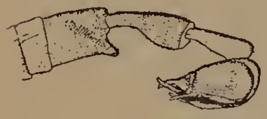

FIG. 313. — Abdomen of *Panorpa rufescens*.

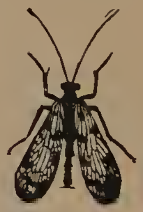

FIG. 312. — *Panorpa*, female.

The scorpion-flies. — The most common members of this order belong to the genus *Panorpa*, of which there are nearly twenty described North American species. Figure 312 represents a female of this genus. In our more common species the wings are yellowish, spotted with black. The males of this genus are remarkable for the peculiar form of the caudal part of the abdomen (Fig. 313). This at first sight reminds one of the corresponding part of a scorpion, and suggested the common name *scorpion-flies* for these insects. But in reality the two are very different; the last segment of the male *Panorpa*, instead of ending in a sting, like that of a scorpion, is greatly enlarged and bears a pair of clasping organs. The tarsal claws are toothed.

The adults are found resting on the surface of foliage of rank herbage growing on the banks of shaded streams and in damp woods where there is a luxuriant undergrowth of herbaceous plants. They feed on dead or injured insects and upon fruits; it appears that they rarely if ever capture living prey.

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* Mecŏptera: *mecos* (μῆκος), length; *pteron* (πτερόν), a wing.

The females lay their eggs in crevices in the earth. The larvæ are caterpillar-like in form; they have three pairs of true legs and eight pairs of abdominal prolegs; and the body is armed with prominent spines (Fig. 314); the larvæ are carnivorous. The transformation takes place in a cell in the ground.

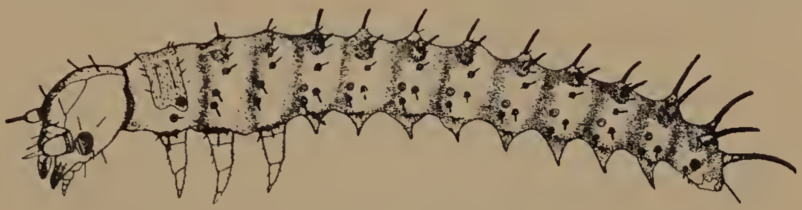

FIG. 314. — Larva of *Panorpa rufescens*, first instar. (After Felt.)

Borēus. — This genus includes small Mecoptera, our species measuring from $\frac{1}{10}$ to $\frac{1}{5}$ of an inch in length, which are often found on snow in winter. The wings of the female are vestigial or wanting; those of the male, imperfectly developed. The ocelli are wanting. The female has a long, protruding ovipositor, which in some species is nearly as long as the abdomen. The larva differs from that of *Panorpa* in lacking the abdominal prolegs. The pupa state is passed in an earthen cell in the ground. Four American species have been described, two from the East and two from the West.

Bĭttacus. — Insects belonging to this genus have long, narrow wings, long legs, and a slender abdomen. They resemble crane-flies very closely when on the wing, but can be distinguished by the presence of two pairs of wings. They are almost as common as *Panorpa;* and, like the scorpion-flies, are found among rank herbage growing on the banks of shaded streams and in damp woods where there is a luxuriant undergrowth of herbaceous plants. When at rest they hang suspended, by their front legs, from some support (Fig. 315). The members of this genus capture and eat living insects. They are enabled to capture their prey by means of their curiously modified tarsi, the last two segments of which are armed with teeth, and the last segment can be folded back against the next to the last segment. In this way there is formed an efficient grasping organ. It is an interesting fact that, while in other predacious insects the fore legs are the chief organs of prehension, in *Bittacus* the hind legs are used for this purpose fully as often as the others, especially when the *Bittacus* is hanging suspended by its fore legs and captures an insect that comes within reach of it.

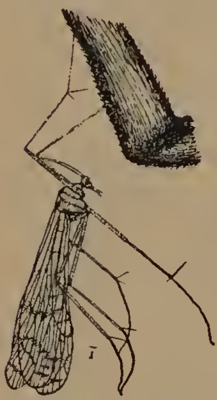

FIG. 315. — Natural position of *Bittacus.* (From Felt.)

Nine North American species of *Bittacus* have been described.

CHAPTER XXIII

ORDER TRICHOPTERA *

The Caddice-flies

The members of this order have four wings; these are membranous and usually more or less densely clothed with long, silky hairs. In the more generalized members of the order, the venation of the wings corresponds closely to that of the hypothetical primitive type with but few or no accessory veins; in some of the more specialized members of the order, the venation of the wings is reduced. The mouth-parts of adults, except the palpi, are vestigial. The metamorphosis is complete.

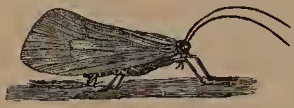
FIG. 316. — Caddice-fly.

The caddice-flies are moth-like insects, which are common in the vicinity of streams, ponds, and lakes, and are frequently attracted to lights at night (Fig. 316). The larvæ of these insects are the well-known caddice-worms; these live in the water, and most of them build cases about their bodies.

In the adult insect, the body-wall is soft, and is thickly clothed with hairs. The two pairs of wings are membranous and usually more or less clothed with long, silky hair. In a few forms the wings are naked. The hind wings are shorter than the fore wings; but they are usually broader. In one species the female is apterous, and in another the wings of the female are vestigial. When not in use the wings are folded roof-like over the abdomen.

The eggs of caddice-flies are round or slightly oval in form. They are laid either in water or upon objects above water from which the larvæ when hatched can find their way into the water. Some species that lay their eggs in water descend below the surface in order to glue their eggs to some submerged support. So far as is known, most caddice-flies, lay their eggs in a mass enveloped either in a cement, by which the mass is glued to some support, or in a gelatinous covering. In the latter case, the covering absorbs water and thus increases greatly in size. The form of the gelatinous mass and the arrangement of the eggs within it are often characteristic of the species (Fig. 317).

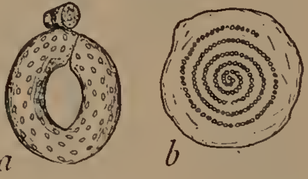

FIG. 317. — Two egg-masses of caddice-flies: *a*, *Phryganea interrupta*; *b*, *Triænodes sp.* (From Lloyd.)

The larvæ of caddice-flies, the caddice-worms, found in this country are aquatic and most of them build portable cases in which they live and which they drag about wherever they go projecting only the front end of the body and the legs from the case when they travel. The cases of different species differ greatly in form and in materials used in their construction; but silk is used in building all of them. This silk, like that of caterpillars, is secreted by modified salivary glands and is emitted through an opening in the labium.

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* Trichŏptera: *trichos* (θρίξ, τρῖχός), the hair; *pteron* (πτερόν), a wing.

Some caddice-worms build their cases entirely of silk; but most of the case-building species use other materials also; these may be grains of sand, small stones, bits of wood, moss, or pieces of leaves; and some species fasten shells of small mollusks to their cases. The materials used are glued together with silk; and the case is lined with silk, so as to form a suitable protection for the soft abdomen.

When the caddice-worms are full-grown they do not leave the water to transform, the pupæ being as truly aquatic as the larvæ. Some of the case-building species change the form and material of their cases at this time; and nearly all of them partly close their cases so as to keep out intruders and silt; but usually provision is made for the ingress of water for respiration. Some species merely cement a stone or grains of sand over each opening of the case; others build a silken lid with a slit in it; and still others build a silken grating in each end of the case. Within these modified cases the larvæ transform to pupæ.

In the case of those caddice-flies that emerge from rapidly flowing water, as the net-building species, the wings expand instantly when the insect reaches the surface of the water and are then fitted for flight; it is evident that if much time were required for the wings to become fit for use, as is the case with most other insects, the wave succeeding that which swept the insect from the water would sweep it back again and destroy it.

The Trichoptera can be regarded as beneficial insects, as the larvæ form an important element in the food of fishes, and especially of the brook trout. Sometimes in cities near rivers, the adults are annoying on account of the great numbers of them that are attracted to lights.

This is a large order and includes several families. Each species of those which make cases builds a particular kind of tube. Some caddice-worms are carpenters, building their houses of straws or sticks placed lengthwise of the body (Fig. 318); but certain species that make their houses chiefly of straws fasten the straws crosswise like the logs of a log-house (Fig. 319). These log-house builders often have the curious habit of decorating their houses by fastening snail-shells to the outside.

FIG. 318. — Case of caddice-worm.

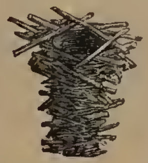

FIG. 319. — Log-cabin type of case.

There are caddice-worm houses closely resembling in plan those just described but differing in appearance, being made of bits of moss. Sometimes the houses are built of leaves; these may be fastened so as to form a flat case; or are arranged in three planes, so as to form a tube, a cross-section of which is a triangle.

Other caddice-worms are masons, building their houses of grains of sand or of small stones. Sometimes these houses are tubes very regular in outline, being composed only of grains of sand fastened together with silk; but certain species of mason caddice-worms fasten larger stones on each side of this tube of sand (Fig. 320). Some of the species that build tubes of sand make spiral houses which very closely resemble in form snail-shells (Fig. 321).

Perhaps the most remarkable species are the net-spinning caddice-worms. The best-known of these are species of the genus *Hydropsy̆che*, the nets of which have been described by many writers.

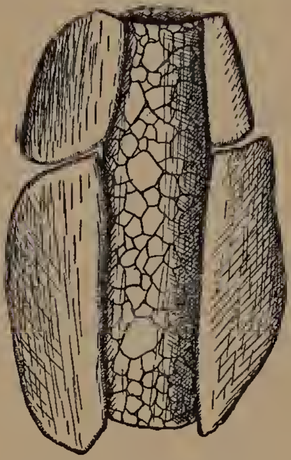

FIG. 320. — Case of *Gœra calcarata*. (After Lloyd.)

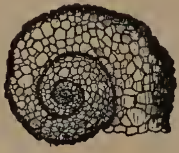

FIG. 321. — Case of *Helicopsyche*. (From Lloyd.)

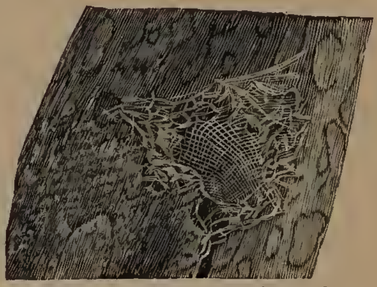

FIG. 322. — Net of *Hydropsyche*.

The larvæ of *Hydropsyche* live only in rapid streams and on the wave-beaten shores of lakes. They do not build portable cases, but live in tubes composed of silk and debris, and fastened permanently in place; sometimes they establish themselves in old worm-holes in submerged wood. The most striking feature in their habits, however, is the fact that each one builds a net for the capture of its food. This net is built adjacent to the tube in which the larva lives; it is funnel-shaped and has at its down-stream end an opening in which is built a strainer. This is a beautiful object, consisting of two sets of regularly spaced strands of silk extending across the opening at right angles to each other (Fig. 322). These nets are often built in crevices between stones; but fully as often they are built up from a flat surface, as on the brink of a waterfall. Much of the coating of dirt with which rocks in such places are clothed in summer is due to its being caught in these nets. Algæ, larvæ, and other small animals in the water that passes through the net are held by the strainer and thus made available to the caddice-worm for food.

CHAPTER XXIV

ORDER LEPIDOPTERA *

The Moths, the Skippers, and the Butterflies

The winged members of this order have four wings; these are membranous, and covered with overlapping scales. The mouth-parts are formed for sucking. The metamorphosis is complete.

The members of this order, the moths, the skippers, and the butterflies, are well known to every observer of nature. Their most easily observed distinguishing characteristic is that which suggested the name of the order, the scaly covering of the wings and body. Every lad that lives in the country knows that the wings of moths and butterflies are covered with dust, which comes off upon one's fingers when these insects are handled. This dust when examined with a microscope is found to be composed of very minute scales of regular form. The body, the legs, and other appendages are also covered with scales.

The scales of Lepidoptera are modified setæ. That is, they are setæ which, instead of growing long and slender as setæ usually do, remain short, but grow very wide as compared with their length. Every gradation in form can be found from the ordinary hair-like form, which occurs most abundantly upon the body, to the short and broad scale, which is best seen upon the wings.

There is a great difference among the insects of this order regarding the regularity of the arrangement of the scales upon the wings. With some of the lower moths the scales are scattered irregularly over the wings. But if the wing of one of the higher butterflies be examined with a microscope, the scales will be found arranged in regular, overlapping rows; the arrangement being as regular as that of the scales on a fish or of the shingles on a roof (Fig. 323). In the upper part of the figure the membrane is represented with the scales removed.

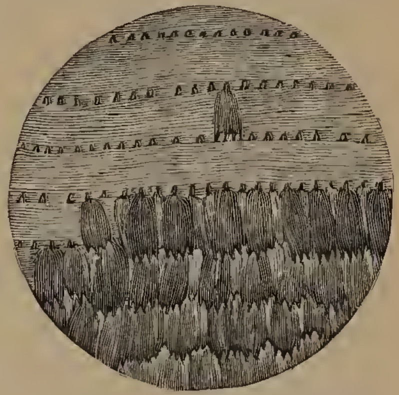

FIG. 323. — Part of wing of butterfly, greatly magnified.

The chief use of the scales on the body is for the protection of the insect. Another use of the scales may be to strengthen the wings. A secondary use of the scales is that of ornamentation; for the beautiful colors and markings of the moths and butterflies are due to the scales. If the scales are removed the colors of the insects are destroyed.

The mouth-parts of moths and butterflies are especially adapted for sucking nectar from flowers. If the head of a butterfly be examined, there will be found a long sucking tube, which when not in use is coiled on the lower side of the head between two forward-projecting appendages. This long sucking tube is composed of the two maxillæ, greatly elongated, and fastened together side by side. In Figure 324 there is represented a side view of the maxillæ of a moth; and in Figure 325 a cross-section of these organs. Each maxilla is furnished with a groove, and the two maxillæ are so fastened together that the two grooves form a tube through which the liquid food is sucked. As a rule the maxillæ of insects of this order are merely fitted for extracting the nectar from flowers, but sometimes the tips of the maxillæ are armed with spines, as shown in Figure 324. This enables the insect to lacerate the tissue of ripe fruits and thus set free the juice, which is then sucked up. Many moths do not eat in the adult state; with these the maxillæ are wanting. The two forward projecting organs between which the maxillæ are coiled when present are the labial palpi. In some moths the maxillary palpi are also developed.

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* Lepidŏptera: *lepido* (λεπίς, λεπίδος), scale; *pteron* (πτερόν), a wing.

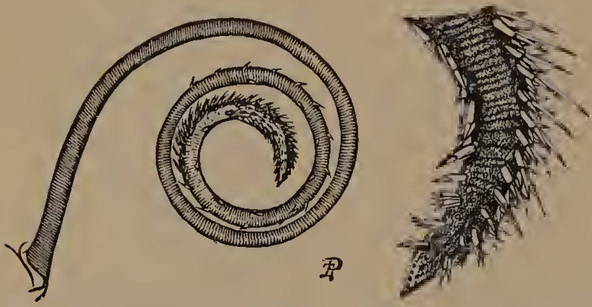
FIG. 324. — Maxillæ of cotton-moth, and tip of same enlarged.

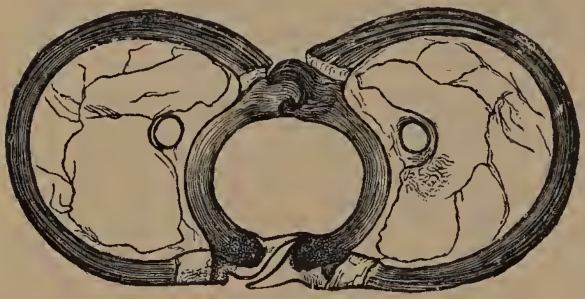
FIG. 325. — Cross-section of maxillæ.

The larvæ of Lepidoptera are known as caterpillars. They vary greatly in form and appearance; but are usually cylindrical, and provided with from ten to sixteen legs, — six thoracic legs, and from four to ten abdominal legs. The thoracic legs, which are finally developed into the legs of the adult, have a hard external skeleton; and are jointed, tapering, and armed at the end with a little claw. The abdominal legs, which are shed with the last larval skin, are thick, fleshy, without joints, elastic or contractile, and are generally furnished at the extremity with numerous, minute hooks (Fig. 326); they are termed prolegs.

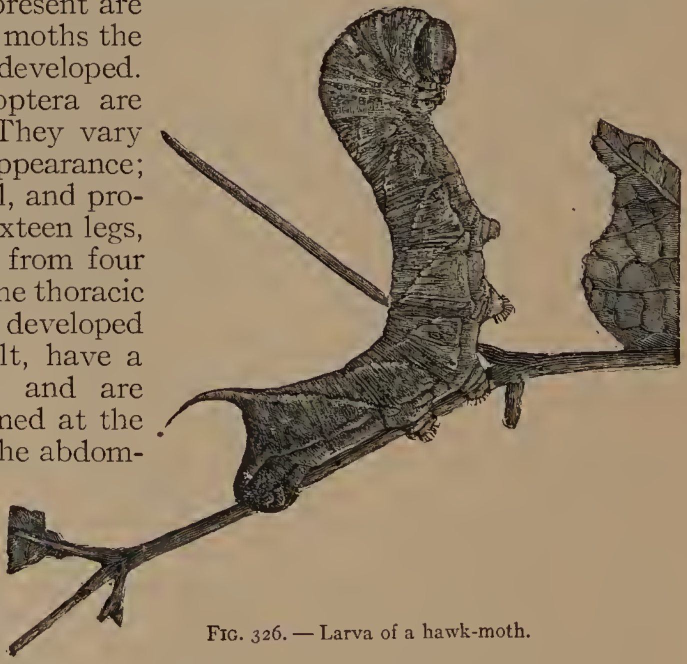
FIG. 326. — Larva of a hawk-moth.

Most caterpillars, except the larvæ of nearly all butterflies, spin cocoons (Fig. 327). In some instances, as in case of the silkworms, a great amount of silk is used in the construction of the cocoon; in others the cocoon is composed principally of the hairs of the larva, which are fastened together with a fine web of silk.

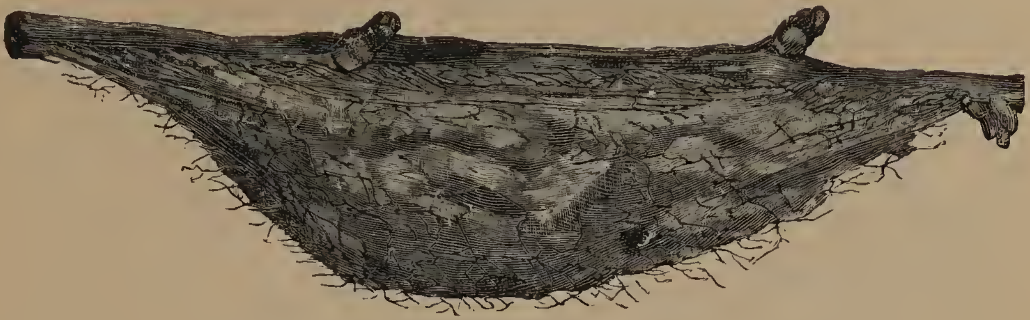

Fig. 327. — Cocoon of a moth.

The pupæ of the Lepidoptera are typically of the obtected type; that is, the developing wings, legs, mandibles, maxillæ, and antennæ are glued to the surface of the body (Fig. 328); but in some of the more generalized forms these appendages are free.

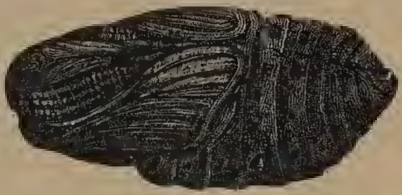

Fig. 328. — Pupa of a moth.

The members of this order as a rule feed upon plants, and are not aquatic; some, as the clothes-moth and the species that destroy scale-insects, feed on animal matter, and a very few feed upon plants below the surface of the water.

More than nine thousand species of Lepidoptera are known to occur in America, north of Mexico. These represent more than sixty families.

We commonly divide the Lepidoptera into two groups; the moths and the butterflies. There is, however, a group within the division of butterflies known as the skippers, which constitutes a fairly well-defined assemblage of forms.

The moths. — These arc the insects commonly called millers. Most of the species fly by night and are frequently attracted to lights. When at rest the wings are either wrapped around the body, or are spread horizontally, or are folded roof-like on the abdomen; exccpt in a few cases they are not held in a vertical position above the body. The antennæ of moths are of various forms; they are usually thread-like or feather-like; only in rare cases are they enlarged towards the tip.

The butterflies. — All of our specics of butterflies fly in the daytime; and, with few exceptions, they fold the wings together above the back in a vertical position when at rest. The antennæ are thread-like, and usually with a club at the tip. It was this feature that suggested the term Rhopalocera, which is applied to them.

The group of butterflies as defined here includes the representatives of two quite distinct superfamilies, the Hesperioidea or skippers, and the Papilionoidea or true butterflies.

The skippers are so called on account of their peculiar mode of flight. They fly in the daytime and dart suddenly from place to place. When at rest they usually hold the wings erect in a vertical position like the true butterflies; often the fore wings are thus held while the hind wings are extended horizontally. The antennæ are thread-like, and enlarged towards the tip; but in most cases the extreme tip is pointed and recurved, forming a hook. The abdomen is usually stout, resembling that of a moth rather than that of a butterfly.

CLASSIFICATION OF THE LEPIDOPTERA

The first step to be taken in the study of the classification of these insects is to become thoroughly familiar with the nomenclature of the wing veins; this is given on pages 32 to 33. It is a good plan to take several of the larger moths and butterflies and make drawings showing the courses of the veins of the wings in each, carefully indicating the names of the veins on the drawings.

As the scales on the lower surface of the wings are more closely applied to the wings than are those on the upper surface, the veins can be best seen when the wings are examined from below. The veins can be rendered more distinct for a few seconds by putting a little 95% alcohol or benzol on the part of the wing to be examined; this can be easily done by means of a camel's-hair brush.

Sometimes it is necessary to remove the scales from a small part of the wing in order to determine the nature of some characteristic; this can be easily done by scratching them off lightly with a pin on the underside only.

The above methods are all that are needed in the majority of cases where the mere determination of an insect is the object. But when a very careful study of the venation of a wing is to be made, it should be bleached and mounted on a card or on a glass slip in order that it may be studied with a compound microscope. The following is the method of bleaching wings: —

1. Remove the wings carefully so as not to break the frenulum if there be one.
2. Dip the wings in alcohol in order to wet them.
3. Immersion for an instant in hydrochloric acid, one part acid to nine parts water, will help but usually not necessary,
4. Put them in Labaraque solution and leave there till the color has been removed from the scales. If a wing bleaches slowly, the process can be hastened by dipping it in the dilute acid and returning it to the Labaraque solution from time to time. This solution can be procured of most druggists. It deteriorates if left exposed in strong light. If it cannot be obtained, use an aqueous solution of chloride of lime.
5. When a wing is bleached put it in alcohol and leave it there three to five minutes. This is to wash off the Labaraque solution. The wing can then be mounted on a card. But it is better to mount it as described below.
6. Put wing on slide in alcohol, blot off excess alcohol, add a drop or two of oil of lavendar, let stand several minutes, put on balsam and cover with thin glass.

Wings bleached and mounted in this way make an important addition to a collection. The slides should be carefully labelled to correspond with the rest.

There are a few special terms used in describing the wings of the Lepidoptera which should be learned: —

Frenulum. — In most moths there is a strong spine or a bunch of bristles borne by the hind wing at the humeral angle (Fig. 329, *f*); this is the frenulum. Its use is to insure the acting together of the two wings of one side. As a rule the frenulum of the male consists of a single strong spine and that of the female when present of two or more bristles.

Jugum. — In one suborder, including only a few rare moths, there exists, instead of a frenulum, a lobe borne near the base of the inner margin of the fore wing (Fig. 333, p. 193); this is the jugum. See suborder Jugatæ.

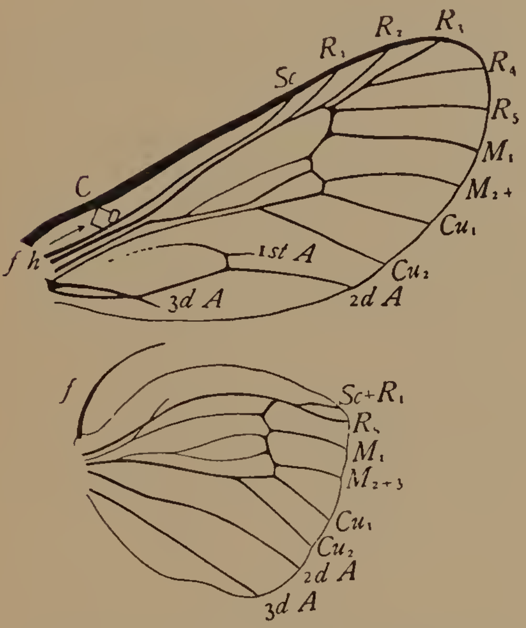

FIG. 329. — Wings of a moth: *f h*, frenulum-hook.

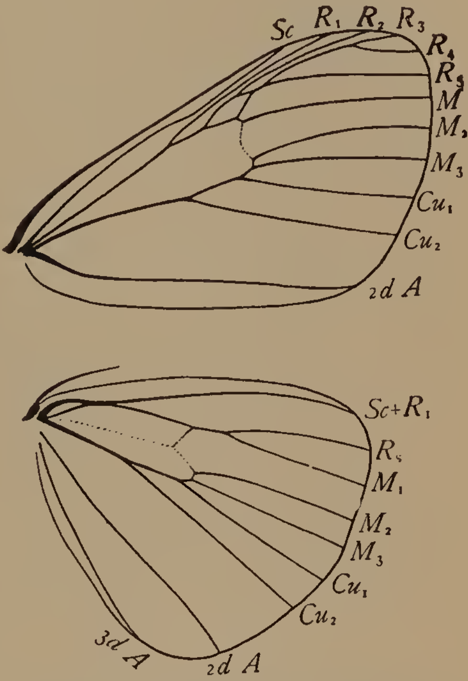

FIG. 330. — Wings of *Hemerocampa leucostigma.*

Discal cell. — Near the centre of the basal part of the fore wing there is a large cell lying between veins R and Cu (Fig. 330); this is the discal cell. In the more generalized Lepidoptera this cell is divided into two parts by the base of vein M (Fig. 330, hind wing); in such cases the cell lying immediately behind vein R is cell R, and that lying immediately behind vein M is cell M.

Patagia. — At the base of each fore wing there is a scale-like appendage; these are the patagia or tegulæ.

In descriptions of Lepidoptera reference is often made to the palpi. These form the double beak-like projection which extends forward from the lower surface of the head. In most Lepidoptera only the labial palpi are well developed; but in some of the more generalized forms the maxillary palpi are also present.

The presence or absence of ocelli is a character which is sometimes of considerable importance. These organs are situated, one on each side, above the compound eye and near its margin. But it requires some skill to find them when they are present, on account of the long scales clothing the head.

The eye cap is also a character of some importance. The first segment of the antennæ of some moths is much broadened and hollowed out and when such moths are at rest with the antennæ folded back this segment covers the eye like a cap.

SIMPLIFIED KEY TO FAMILIES TO LEPIDOPTERA*

A. Hind wing with eleven veins (counting along the margin) besides anals.

B. Expanse over 1 inch; mouth-parts rudimentary. p. 192 .... HEPIALIDÆ

BB. Expanse about ½ inch; mouth-parts functional.

C. Mouth-parts for biting; middle tibia unarmed. p. 192 .... MICROPTERYGIDÆ

CC. Mouth-parts for sucking (the usual spiral tongue), middle tibia ending in a single spur. p. 192 .... ERIOCRANIIDÆ

AA. Hind wing with only *seven* veins (or less) besides anals.

B. Membrane of hind wing lanceolate or linear, narrower than its own fringe.

C. First joint of antennæ very large and spoon shaped, completely covering the eye when folded back (an "eye-cap"). Cell of fore wing at least fully formed; palpi rudimentary, drooping, apex of fore wing sharply bent up or down. p. 202 .... LYONETIIDÆ

CC. No eyecap.

D. A row of bristles on outer side of labial palpus (besides the usual hair and scales). Maxillary palpi usually conspicuous at base of tongue (between labial palpi), and folded, but absent in common clothes-moth. Head very rough.

E. Wing-membrane with microscopic spinules between the sockets of the scales; female with piercing ovipositor; Sc of hind wing usually apparently forked into equally stout branches at base, or very stout; antenna smooth-looking (either with both rows of scales on each segment lying flat, or finely pubescent) or else longer than fore wing. p. 195 .... INCURVARIIDÆ

EE. Wing-membrane not spinulated; female with an extensible, tubular, soft and hairy ovipositor; Sc of hind wing apparently simple, connected by a weak vein to base of R or none; antenna with outer whorl of scales on each segment usually raised; rough-looking, not longer than fore wing. p. 199 .... TINEIDÆ

DD. No bristles distinct from the usual hair and scales. Maxillary palpus inconspicuous, or projecting straight forward.

E. Fore tibia without an epiphysis (antenna-cleaner) on its inner face. p. 204. .... COLEOPHORIDÆ

EE. Fore tibia with an epiphysis along its middle part.

F. Fore wing with four veins running from discal cell to costa, and five or six to below apex (inner margin). p. 207 .... YPONOMEUTIDÆ

FF. Fore wing with at least as many veins running to costa as to inner margin from discal cell.

G. Hind tibia hairy above; cell of fore wing very large, with an accessory cell cut off from it by a weak vein. p. 202 .. TISCHERIIDÆ

GG. Hind tibia smooth-scaled, or with a regular series of bristles; cell of fore wing narrow, accessory cell (1st R_3) not distinguishable. p. 203 .... GRACILARIIDÆ

BB. Hind wing (membrane) notched below apex, frequently narrower than its own fringe. p. 206 .... GELECHIIDÆ (part)

BBB. Hind wing divided in 3 feathers. p. 217 .... PTEROPHORIDÆ

BBBB. Hind wing broad, not notched, and broader than its own fringe.

C. Antennæ swollen toward tip (clubbed), no frenulum.

D. Bases of antennæ separated by a space wider than their own thickness, fore wing with all branches of R, M, and Cu, (10 in all) present and arising separately from discal cell.

E. Large butterflies, thorax much wider than head. p. 258 ... MEGATHYMIDÆ

EE. Medium or small butterflies, expanding rarely over 2 inches; head wider than body. p. 259 .... HESPERIIDÆ

DD. Antennæ closer together at base, branches of R partly stalked or united, there being only 9 (usually 8 or less) veins arising separately from discal cell.

E. Fore wing with 3d A short and curved but running down free to inner margin, hind wing with only 1 anal. Cu apparently 4-branched. p. 262. .... PAPILIONIDÆ

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* This key was drawn up by Dr. W. T. M. Forbes.

EE. Fore wing without a free 3d A, hind wing with 2 anal veins. Cu (in our species) apparently 3-branched.

F. Fore legs normal in size, used for walking. Usually 1 radial vein lost.

G. M2 arising from middle of end of discal cell. Head very narrow, the antennæ slightly encroaching on the eye. p. 281......LYCÆNIDÆ

GG. M2 arising from upper angle of discal cell or even (usually) stalked with R3–5. Head wider, the eye a complete circle. p. 265. ....PIERIDÆ

FF. Fore legs reduced, often brush-like (except some ♀'s), not used for walking. Fore wing with all veins (except 1st A and 3d A) almost always preserved. p. 268............................NYMPHALIDÆ

CC. Antennæ not swollen toward tip, or if so (Sphingidæ, Agaristidæ, etc.) with frenulum well developed.

D. Hind wing with Sc and R closely parallel or fused *beyond* where R leaves the discal cell. (Closer than they are along the discal cell); base of M not preserved in cell.

E. Wings long and narrow, fore wing 4 × as long as wide; wings interlocked by rows of spines near inner edge of fore wing and costa of hind wing. p. 207..ÆGERIIDÆ

EE. Wings relatively broader, hind wing but little longer than broad. Wings not interlocked.

F. Hind wing with three anal veins, 1st A being preserved. p. 212. ....PYRALIDIDÆ

FF. Hind wing with 1 or 2 anal veins. Body extremely stout, projecting far beyond the wings which are narrow. p. 218........SPHINGIDÆ

DD. Hind wing with Sc and R widely separated beyond end of discal cell (Sc rarely wholly lost); or (some Cossidæ) with base of M fully preserved, forked in cell.

E. Fore wing with M2 arising more than half as far from M3 as from M1, Cu therefore apparently 3-branched.

F. Hind wing with Sc and R touching, closely parallel or fused no second quarter of discal cell, then diverging before end of discal cell.

G. Base of Sc sharply angled, and connected by a more or less distinct humeral vein to base of frenulum. Usually slender moths. p. 223. ....GEOMETRIDÆ

GG. Sc gently curved at base, not connected to frenulum-base. Stout moths.

H. Radius pectinate (with R1, 2, 3, 4 given off successively from the stem that leads to R5); frenulum rudimentary. p. 255..BOMBYCIDÆ

HH. R3 and 4 most closely associated; frenulum functional, conspicuous in male. p. 227..........................NOTODONTIDÆ

FF. Sc and R of hind wing diverging sharply almost from base.

G. Hind wing with two anal veins, upper discocellular vein (the portion of vein bounding the discal cell between the points where R_s and M1 leave it) short and transverse. p. 246......CITHERONIIDÆ

GG. Hind wing with only one anal vein or upper discocellular vein long and longitudinal (usually both). p. 249..........SATURNIIDÆ

EE. Fore wing with M2 associated with Cu-stem, Cu therefore apparently *4-branched.*

F. Sc and R of hind wing fused for second fourth of discal cell or more.

G. Vein 1st A preserved in both wings.

H. Wings light colored, tongue absent. p. 197........MEGALOPYGIDÆ

HH. Wings largely blackish, tongue strong. p. 197...PYROMORPHIDÆ

GG. Vein 1st A lost in both wings (fore wing with 1 anal, hind wing with two). p. 242..................................ARCTIIDÆ

FF. Sc and R more shortly fused, or not at all.

G. Vein 1st A, preserved in one and usually both wings.

H. Vein 1st A, a well-marked tubular vein (i.e., an ordinary vein) on fore wing, at least toward margin.

I. Spurs of tibiæ longer than width of tibiæ, normally over twice as long, if somewhat shorter with base of media (in cell) simple, dividing the cell into two parts.

J. Fore wing with R3 and 4 stalked (forking over apex) or united, in the latter case with only two radial veins running to costa, and the third preserved vein to the apex.* p. .198 .... EUCLEIDÆ

JJ. Fore wing with all veins preserved and separate, or with R4 and 5 stalked or united, in that case with three veins running to costa before the one that goes to apex.

K. Fore wing with R5 running to costa.

L. Palpus upturned and sickle-shaped, with long, pointed third joint. p. 205. (in part)...........ŒCOPHORIDÆ

LL. Palpus with third joint blunt, and either projecting forward or very short.

M. Cu2 arising not far from middle of inner margin of cell; palpus without bristles (Peronea) p. 209. .... TORTRICIDÆ

MM. Cu2 arising more than ¾ way out on cell; palpus normally with stiff bristles on outer side of second joint. p. 199, 195 .... TINEIDÆ and INCURVARIIDÆ

KK. Fore wing with R5 running to outer margin below apex.

L. Fore wing with R4 and 5 strongly stalked or united (one vein missing); hind wing with R and M_1 widely separated at origin from cell; palpus upturned, sickle-shaped, with third joint long and pointed. p. 205 .... ŒCOPHORIDÆ (part)

LL. Fore wing with R4 and 5 separate at origin *or* (rarely) with them stalked, but with R and M1 of hind wing stalked or closely approximate at origin; palpus with third segment usually short and blunt.

M. Head smooth; palpus closely scaled, the third joint usually upturned and continuing the curve of the palpus; base of M (in cell) rarely preserved, and if so, bisecting cell. p. 207..............YPONOMEUTIDÆ

MM. Head and palpus rough-scaled, the third joint projecting forward, or stumpy and well set off; base of M running diagonally, in its outer part close to hind margin of cell, rarely lost. p. 209......TORTRICIDÆ

II. Spurs of tibia rudimentary, or if about as long as width of tibia, with M forked in cell.

J. Base of M forked in cell, enclosing an intercalated cell (1st M2); spurs of tibiæ distinct. p. 196 ....COSSIDÆ

JJ. Base of M simple, dividing the cell in two parts. Tibiæ normally with spurs absent. p. 200............PSYCHIDÆ

HH. Vein 1st A, absent in fore wing. Palpus sickle-shaped, usually smooth, with long, pointed third joint. p. 205......GELECHIIDÆ

GG. Vein 1st A, lost in both wings.

H. Frenulum present.

I. "Micros" (wings soft and loosely scaled) fringe lengthened at anal angle of hind wing, hind wing with R_1 preserved as a strong vein connecting Sc and R near base, and palpi long and sickle-shaped. p. 205..........................GELECHIIDÆ

II. "Macros" (wings strong) fringe hardly longer at anal angle of hind wing, R_1 of hind wing lost by fusion of Sc and R or else palpi very short.

J. Ocelli absent, hind wing with Sc and R merely touching ⅓ to ½ way out on discal cell or entirely separate. p. 232. .... LYMANTRIIDÆ

JJ. Ocelli present (easily visible behind eye without denuding) Sc and R fused a short distance, or touching much nearer to base.

K. Antennæ swollen toward apex. p. 241........AGARISTIDÆ

KK. Antennæ regularly tapering. p. 234........NOCTUIDÆ

HH. Frenulum absent. p. 256......................LASIOCAMPIDÆ

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* If the wing is bluntly rounded the middle of the curving tip is viewed as the apex.

THE MOTHS

There are thousands of species of moths many of which are commonly known as millers. Most of them are nocturnal in their activities and frequently come to lights in large numbers. When the individuals are at rest the wings are nearly always either wrapped around the body, or are spread horizontally, or are folded roof-like on the abdomen. Although the antennæ are of various forms, they are usually thread-like or feather-like and only rarely are they enlarged at the tip.

Suborder JUGATÆ

The Jugate Lepidoptera

The American representatives of this suborder are rare moths, which the student beginning the study of insects is not likely to meet. They can be easily recognized by the peculiar structure of the hind wings, which resemble the fore wings in form and in venation (Fig. 331). In all other Lepidoptera, the two pairs of wings differ in form, and the hind wings are furnished with fewer veins than are the fore wings.

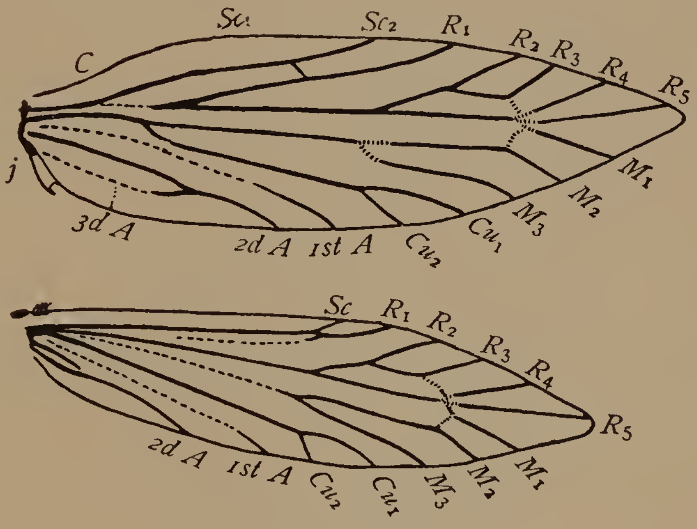

FIG. 331. — Wings of *Micropteryx.*

The most important character of the suborder, and the one to which its name refers, is the organ which aids in holding the two wings of each side together. There projects backward from the inner margin of the fore wing near its base a small lobe (Fig. 331, *j*), which extends, under or over the costal margin of the hind wing; while the greater part of the inner margin of the fore wing overlaps the hind wing. This arrangement assures the acting together of the two wings, at least in the downward stroke.

This projecting lobe in its typical form is named the *jugum* or yoke; and the moths possessing this projection are termed the Jugatæ or the Jugate Lepidoptera.

The suborder Jugatæ, as now more commonly limited, includes several families, representatives of three of which have been found in America; these are the Micropterygidæ, the Eriocraniidæ, and the Hepialidæ.

Family MICROPTERYGIDÆ

The Mandibulate Jugates

The members of this family are small insects which resemble tineid moths in general appearance. As with other members of the suborder Jugatæ, the venation of the hind wings closely resembles that of the fore wings (Fig. 331). But these insects differ from all other Lepidoptera in that the adult moths have well-developed and efficient mandibles. This remarkable character, together with the lack of certain internal organs, has caused some authorities to take these moths out of the Lepidoptera and to put them in a separate order.

The abdomen of the female has ten segments but there is no ovipositor. The adults feed on pollen. The larvæ of our American forms do not seem to have been observed.

Family ERIOCRANIIDÆ

The Haustellate Jugates

The members of this family, like those of the preceding one, are small insects which resemble tineid moths in general appearance. In this family the mandibles of the adult are vestigial; the maxillæ are formed for sucking, each maxilla forming half of a long sucking-tube, as in higher Lepidoptera; and the females have a piercing ovipositor. The jugal lobe of the fore wing extends back above the base of the hind wing and is clasped over an elevated part of the hind wing, thus being of the type described as a fibula.

The best known species, *Mnemŏnica auricyănea*, is gold with purple spots and has a wing-expanse of about ½ an inch. The larva mines in the leaves of chestnut, oak and chinquapin, making a large blotch mine. When grown it goes into the ground, spins a cocoon and changes to a pupa in the following winter.

The pupa has long, arm-like toothed mandibles, with which it cuts the tough cocoon and with which it digs its way up to the surface of the ground; the adult emerges in April.

Family HEPIALIDÆ

The Swifts or the Macrojugatæ

The members of this family are of medium or large size. Figure 332 represents in natural size one of the larger of the American species, but many exotic species are larger than this one. Our smaller species have a wing-expanse of at least one inch. Our best-known species are brown or ashy-gray in color, with the wings marked with silvery-white spots.

It is said that these moths fly near the earth, and only in the evening after sunset, hiding under some low plant, or clinging to the stalk of an herb during the day. Some of them fly with extreme rapidity, with an irregular mazy flight, and have, therefore, been named *swifts* by collectors.

In the Hepialidæ the posterior lobe of the fore wing is a slender, finger-like organ, which is stiffened by a branch of the third anal vein, and which projects beneath the costal margin of the hind wing. As the greater part of the inner margin of the fore wing overlaps the hind wing, the hind wing is held between the two. This is the type of posterior lobe of the fore wing to which the term *jugum* is applied (Fig. 333).

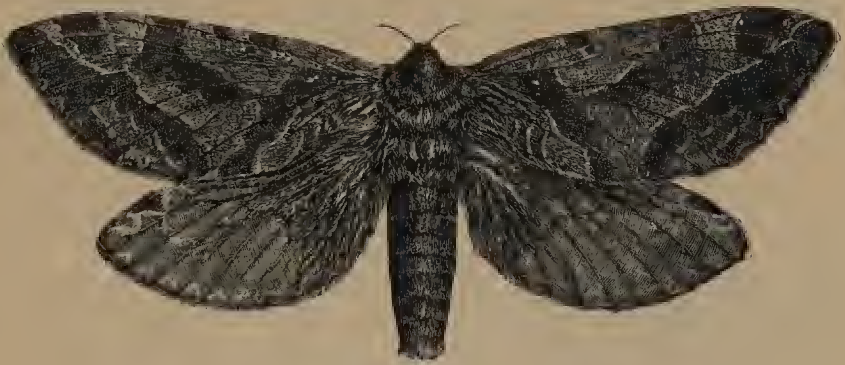

Fig. 332. — *Sthenopis purpurascens.*

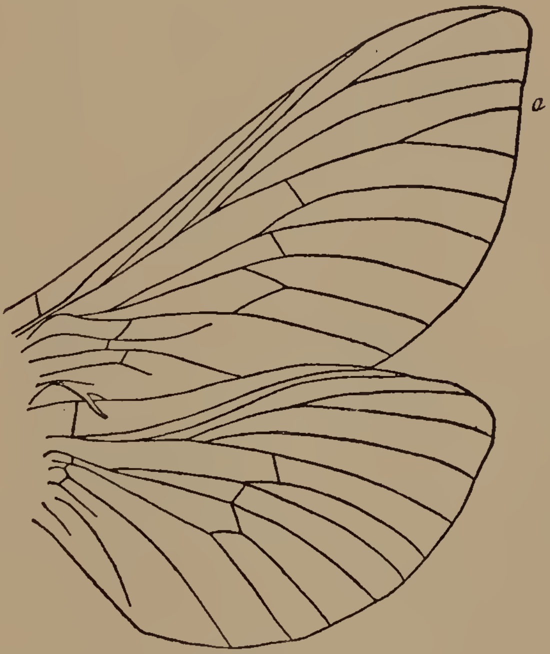

Fig. 333. — Wings of a hepialid, seen from below; *a*, accessory vein.

The larvæ are normal caterpillars and furnished with sixteen legs; they feed upon wood or bark, and are found at the roots or within the stems of plants. They transform either in their burrows, or, in the case of those that feed outside of roots, within loose cocoons. The pupæ have transverse rows of teeth on the abdominal segments; these aid them in emerging from their burrows.

This family is represented in our fauna by two genera, *Hepialus* and *Sthenopis*.

Suborder FRENATÆ

The members of the Frenatæ are most easily recognized by the fact that the venation of the hind wings differs markedly from that of the fore wings, being much more reduced. In this suborder, vein R_1 of the hind wings coalesces with subcosta, the two appearing as a single vein, except that, in some cases, a short section of the base of R_1 is distinct, presenting the appearance of a cross-vein between radius and subcosta (Fig. 334, R_1).

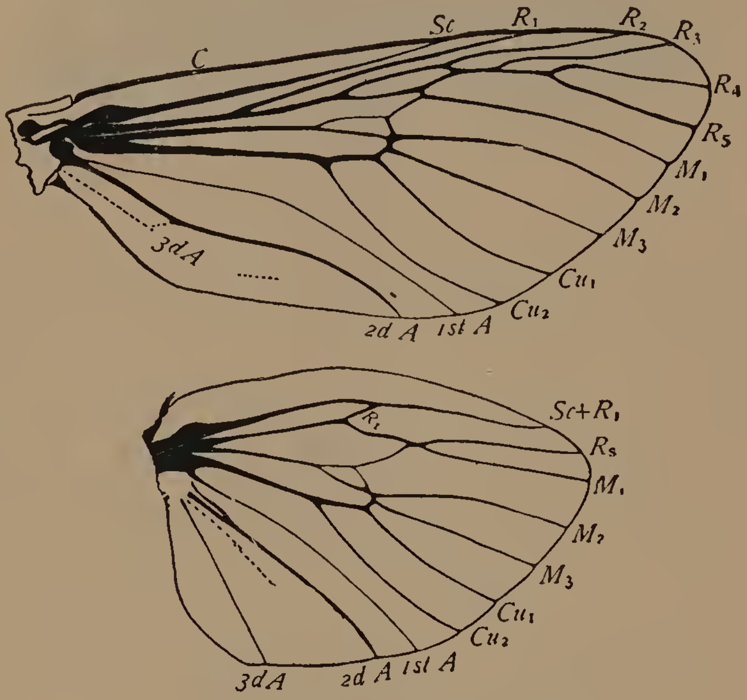

FIG. 334. — Wings of *Prionoxystus robiniæ*.

The essential characteristic of the Frenatæ is that they are descendants of those primitive Lepidoptera in which the two wings of each side were united by a frenulum. This fact should be clearly understood, for in many of the Frenatæ the frenulum has been lost. The loss of the frenulum in these cases is due to its having been supplanted by a substitute for it, by an enlarged humeral area of the hind wings, which causes the two wings of each side to overlap to a great extent. This overlapping of the two wings insures their synchronous action; and the frenulum, being no longer needed for this purpose, is lost.

As a rule the frenulum of the female, when present, consists of several bristles, while that of the male consists of a single strong, spine-like organ.

The frenulum-hook, which is present in the males of most moths, is a membranous fold on the lower surface of the fore wing for receiving the end of the frenulum, and thus more securely fastening the two wings together (Fig. 329, *f h*). As a rule, the frenulum hook arises from the membrane of the wing near the base of cell C.

Family INCURVARIIDÆ

An interesting representative of the family Incurvariidæ is the maple-leaf cutter, *Paraclemĕnsia acerifoliĕlla*. The larva infests the leaves of maple, and occasionally is so abundant that it does serious injury. The larva is at first a leaf-miner, but later it is a case-bearer.

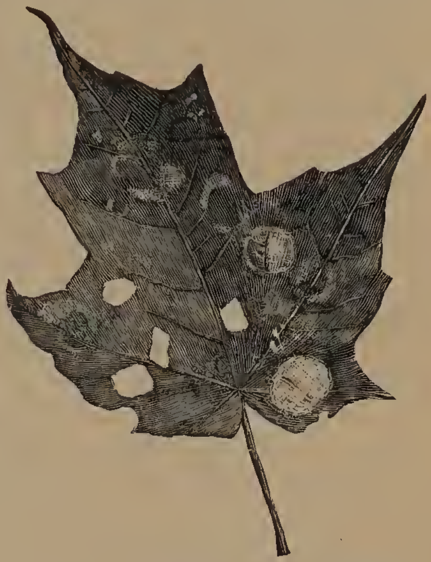

FIG. 335. — Leaf infested by the maple-leaf cutter.

The leaves of an infested tree present a strange appearance (Fig. 335). They are perforated with numerous elliptical holes, and marked by many, more or less perfect, ring-like patches in which the green substance of the leaf has been destroyed but each of which incloses an uninjured spot. These injuries are produced as follows: the larva, after living for a time as a leaf-miner, cuts an oval piece out of a leaf, places it over its back, and fastens it down with silk around the edges. This serves as a house beneath which it lives. As it grows, this house becomes too small for it. It then cuts out a larger piece which it fastens to the outer edges of the smaller one, the larva being between the two. Then it crawls halfway out upon the leaf, and by a dexterous lifting of the rear end of its body turns the case over so that the larger piece is over its back. When it wishes to change its location it thrusts out its head and fore legs from the case and walks off, looking like a tiny turtle. When it wishes to eat, it fastens the case to the leaf and, thrusting its head out, eats the fleshy part of the leaf as far as it can reach. This explains the circular form of the patches, the round spot in the center indicating the position of the case. The insect passes the winter in the pupa state within its case, which falls to the ground with the infested leaf. The moth is of a brilliant steel-blue or bluish-green color, without spots but with an orange-colored head; it appears in early summer.

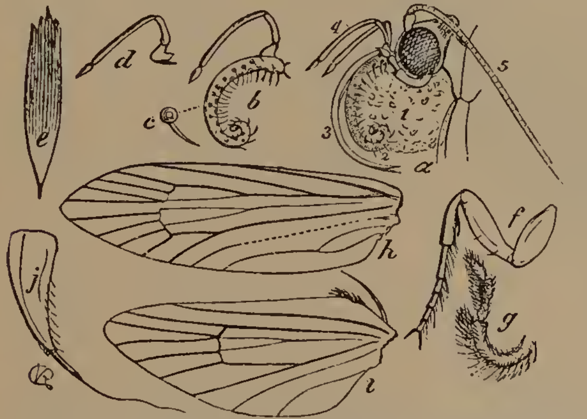

FIG. 336. — *Tegeticula alba:* *a*, side view of head and neck of female denuded; *1*, load of pollen; *2*, maxillary tentacle; *3*, maxillæ; *4*, maxillary palpi; *5*, antennæ; *b*, maxillary tentacle and palpus. All enlarged. (From Riley.)

The yucca moth, *Tegetĭcula alba*, is another interesting member of this family. This species infests *Yucca filamentosa*, a plant not fitted for self-pollination or for pollination by insects in the ordinary ways; in fact, it is pollinized only by moths of the genus *Tegeticula*, the larvæ of which feed on its seeds. This is one of the few cases in which a particular plant and a particular insect are so specialized that each is dependent upon the other for the perpetuation of the species. In the female moth, the maxillæ are each furnished with a long, curled, and spinose appendage, the *maxillary tentacle* (Fig. 336), fitted for the collection of pollen. After collecting a large load of pollen, often thrice as large as the head (Fig. 336), the female moth places her eggs, by means of her long, extensile ovipositor, into an ovary, usually of another flower than that from which the pollen was collected. After oviposition, the moth runs up to the tip of the pistil and thrusts the pollen into the stigmatic opening. Thus is insured the development of seeds, upon which the larvæ hatched from the eggs placed in the ovary are to feed. As many more seeds are developed than are needed by the larvæ, the perpetuation of the yuccas is assured.

The full-grown larva leaves the yucca pod and makes its way to the ground, where it spins a dense cocoon several inches below the surface. The adult moth has a wing-expanse of about 1 inch. The wings are silvery-white above.

Family Cossidæ

The Carpenter-moths

This family includes moths with spindle-shaped bodies, and narrow, strong wings, some of the species resembling hawk-moths quite closely in this respect. The larvæ are borers; many of them live in the solid wood of the trunks of trees. The wood-boring habits of the larvæ suggest the popular name *carpenter-moths* for the insects of this family.

These moths fly by night and lay their eggs on the bark of trees, or within tunnels in trees from which adult carpenter-moths have emerged. The caterpillars are nearly naked, and, although furnished with prolegs as well as true legs, are grub-like in form. The pupa state is passed within the burrow made by the larva. When ready to change to an adult, the pupa works its way partially out from its burrow. This is accomplished by means of backward-projecting saw-like teeth, there being one or two rows of these on each abdominal segment. After the moths have emerged, the empty pupa-skins can be found projecting from the deserted burrows.

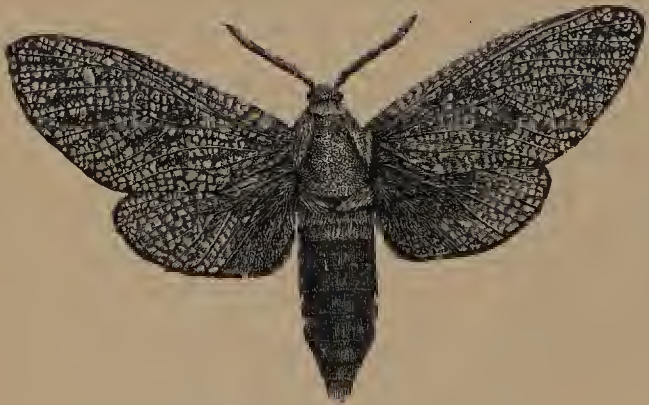

Fig 337. — *Prionoxystus robiniæ*, female.

The carpenter-moths are of medium or large size. The antennæ of the males are mostly bipectinate; those of the females are either very slightly bipectinate or ciliate. In a few species the antennæ are lamellate. The ocelli are wanting, and the maxillæ are vestigial. See Figure 334 for type of venation.

The locust-tree carpenter-moth, *Prionoxӯstus robĭniæ.* — Figure 337 represents the female, natural size. The male is but little more than half as large as the female. It is much darker than the female, from which it differs also in having a large yellow spot, which nearly covers the outer half of the hind wings. The moths fly in June and July; the larvæ bore in the trunks of locust, oak, poplar, willow, and other trees. It is supposed that the species requires three years to complete its transformations. It is found from the Atlantic Coast to California.

The lesser oak carpenter-worm, *Prionoxȳstus macmŭrtrei.* — This is a slightly smaller species than the preceding. The larva bores in the trunks of oak in the East. The moth has thin, slightly transparent wings, which are crossed by numerous black lines. The male is much smaller than that of *P. robiniæ*, and lacks the yellow spot on the hind wings.

The leopard-moth, *Zeuzēra pyrīna.* — This species is white, spotted with numerous small, black spots, which suggested its common name. The adult has a wing-expanse of from 1½ to 2 inches. It is a European species, which was first observed in the vicinity of New York City in 1882; since that time it has spread to other parts of the East. The larva is a very injurious borer in many species of trees and shrubs. The young larvæ bore in the small twigs; later they migrate to larger limbs or to the trunk.

Family PYROMORPHIDÆ

The Smoky-moths

There are but few insects in our country pertaining to this family; only fifteen species are now recognized, but these represent six genera. These are small moths, which are chiefly of a smoky-black color; some are marked with brighter colors; the wings are thinly scaled; and the maxillæ are well developed. The larvæ are clothed with tufted hair; they have five pairs of prolegs, which are provided with normal hooks.

The grape-leaf skeletonizer, *Harrĭsīna americāna,* is a well-known member of this family which is widely distributed throughout the eastern United States from New England to Florida and westward to Missouri and Arizona.

The wings of this moth are long and narrow (Fig. 338); the abdomen is long, and widened towards the caudal end. It is greenish-black in color, with the prothorax reddish-orange. The larva feeds on the leaves of grape and of the Virginia creeper. An entire brood of these larvæ will feed side by side on a single leaf while young. This species rarely becomes of economic importance.

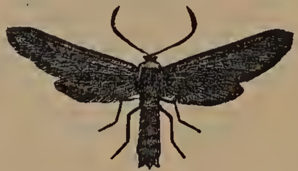

FIG. 338. — *Harrisina americana.*

Family MEGALOPYGIDÆ

The Flannel-moths

In this family the wings are heavily and loosely scaled, and mixed with the scales are long, curly hairs; these give the wings the appearance of bits of flannel. It is this that suggested the common name of these moths. The body is stout and clothed with long hairs. In these moths the maxillæ are vestigial. The larvæ are remarkable for the possession of seven pairs of prolegs; these are borne by abdominal segments 2 to 7 and 10; but those of segments 2 and 7 are without hooks. The setiferous tubercles bear large numbers of fine setæ; so that the body is densely hairy; and interspersed among the fine setæ are venomous setæ.

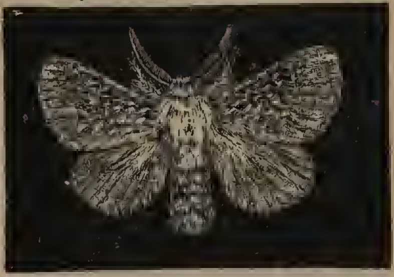
Fig. 339. — *Lagoa crispata*, male.

The crinkled flannel-moth, *Lagōa crispāta*, is cream-colored, with the fore wings marked with wavy lines of crinkled black and brownish hairs. The male is represented in Figure 339; the female is larger, expanding 1½ inches. In the female the antennæ are very narrowly pectinate.

The larvæ feed on many trees and shrubs, including oak, elm, apple, and raspberry. They are short, thick, and fleshy, and are covered with a dense coat of long, silky, brown hairs, which project upward and meet to form a ridge or crest along the middle of the back; interspersed among these fine hairs are venomous setæ.

The cocoons are of a firm, parchment-like texture, covered with a thin web of rather coarse threads. Mixed with the silk of the cocoon are hairs of the larva. The cocoon is similar to that of the next species.

The puss-caterpillar moth, *Megalopȳge operculāris*, is somewhat smaller than the preceding one; the male has a wing-expanse of about 1 inch and the female of about 1½ inches. The fore wings are umber-brown at base, fading to pale yellow outwardly; they are marked with wavy lines of white and blackish hairs, and the fore margins are nearly black. The larvæ are similar to those of the preceding species. The cocoon is provided with a hinged lid (Fig. 340).

This species is found from North Carolina to Texas. The larva is a very general feeder; it is often found on oak. It is a seriously nettling caterpillar often causing distinct irritation when it comes in contact with one's skin.

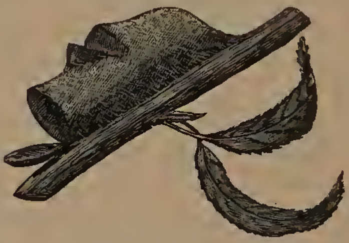
Fig. 340. — Old cocoon of *Megalopyge opercularis*.

Family Eucleidæ *

The Slug-caterpillar Moths

One often finds on the leaves of shrubs or trees, elliptical or oval larvæ that resemble slugs in the form of the body and in their gliding motion. As these are the larvæ of moths they have been termed *slug-caterpillars;* but they present very little similarity in form to other caterpillars. The resemblance to slugs is greatly increased by the fact that the lower surface of the body is closely applied to the object upon which the larva is creeping, the thoracic legs being small and the prolegs wanting. There is, however, on the ventral side of the abdomen a series of sucking-disks, which serve the purpose of prolegs. The head of the larva is small and retractile. In some species the body is naked; in others it is clothed with tufts of hair; and in others there is an armature of branching spines. Several species bear venomous setæ.

The larvæ when full-grown spin very dense cocoons of brown silk;

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* This family is termed the Cochlidiidæ by some writers, and by others the Limacodidæ.

these are egg-shaped or nearly spherical, and are furnished at one end with a cap which can be pushed aside by the adult when it emerges (Fig. 341). The cocoons are usually spun between leaves.

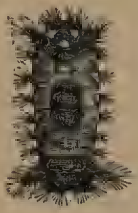

FIG. 342. — *Sibine stimulea*, larva.

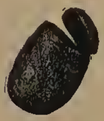

FIG. 341.

The moths are of medium or small size; the body is stout, and the wings are heavily and loosely scaled. The maxillæ are vestigial. These moths vary greatly in appearance, and many of them are very prettily colored.

The following are some of the better known species of this family.

The saddle-back caterpillar, *Sibīne stimūlea.* — This larva can be recognized by Figure 342. Its most characteristic feature is a large green patch on the back, resembling a saddle-cloth, while the saddle is represented by an oval purplish-brown spot. The moth is dark, velvety, reddish-brown, with two white dots near the apex of the fore wings. The larva feeds on oaks and other forest trees. This is one of the species that are armed with venomous setæ.

The spiny oak-slug, *Euclēa delphĭnii.* — This larva (Fig. 343) is one of the most common of our slug-caterpillars and one of those that are armed with venomous setæ. It feeds on the leaves of oak, pear, willow, and other trees. The moth (Fig. 344) is cinnamon-brown, with a variable number of bright green spots on the fore wings.

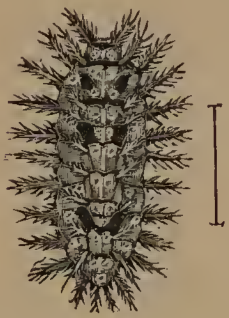

FIG. 343. — *Euclea delphinii*, larva.

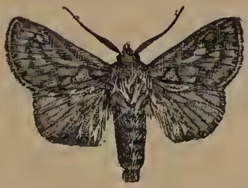

FIG. 344. — *Euclea delphinii.*

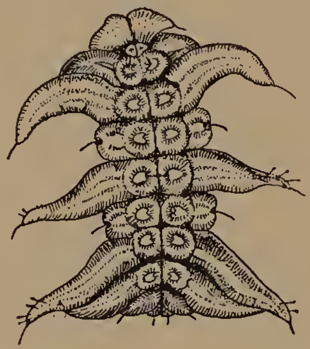

FIG. 345. — *Phobetron pithecium*, larva. (After Dyar.)

The hag-moth, *Phŏbetron pithēcium.* — The common name *hag-moth* is applied to the larva of this species on account of its remarkable appearance (Fig. 345). It bears nine pairs of fleshy appendages which are covered with brown hairs. In the full-grown larva the third, fifth, and seventh appendages are longest; these are twisted up and back, and suggest the disheveled locks of a hag. This larva feeds on various low shrubs and the lower branches of trees. At the time of spinning, the larva sheds the fleshy processes, and they remain on the outside of the cocoon.

Family TINEIDÆ

The head is usually clothed with erect hair-like scales. The antennæ are shorter than the front wings. The maxillæ are usually small or vestigial. The maxillary palpi are usually large and folded. The labial palpi are short and clothed with bristles. In the typical genera the venation of the wings is quite generalized (Fig. 346), the base of media being preserved in both fore and hind wings and all of the veins characteristic of the Frenatæ being present; but in other genera the venation is somewhat reduced.

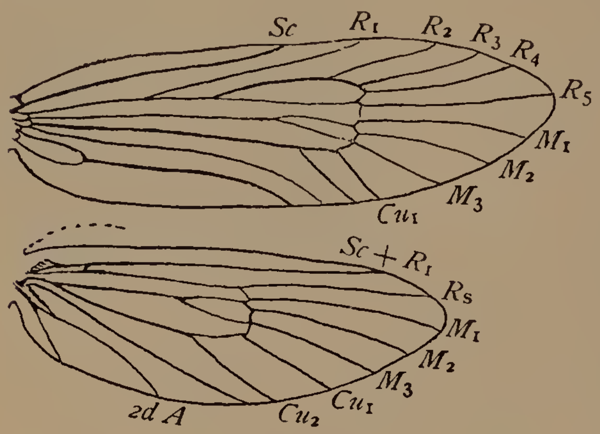

FIG. 346. — Wings of *Tinea parasitella*. (After Spuler.)

Many of the larvæ are case-bearers; many are scavengers or feed on fungi; some feed on fabrics, especially those that contain much wool; few if any feed on leaves.

This is a large family. More than one hundred twenty-five North American species are already known; fifty of these belong to the genus *Tinea*. To this family belong the well-known clothes-moths.

The naked clothes-moth, *Tinēola bisselliĕlla*. — This is our most common clothes-moth. Although the larva spins some silk wherever it goes, it does not make a portable case; it is, therefore, named the naked clothes-moth. But when the larva is full-grown it makes a cocoon, which is composed of fragments of its food-material fastened together with silk. The adult is a tiny moth with a wing-expanse of from $\frac{1}{2}$ to $\frac{3}{4}$ inches; it is of a delicate straw-color, without dark spots on its wings.

The case-bearing clothes-moth, *Tĭnea pellionĕlla*. — The larva of this species is a true case-bearer, making a case out of bits of its food-material fastened together with silk. The case is a nearly cylindrical tube open at both ends. The pupa state is passed within the case. The adult is a small, silky, brown moth, with three dark spots on each fore wing. It expands about $\frac{1}{2}$ of an inch.

The tube-building clothes-moth or the tapestry-moth, *Trichŏphaga tapetiĕlla*. — The larva of this species makes a gallery composed of silk mixed with fragments of cloth. This gallery is long and winding and can be easily distinguished from the case of the preceding species. The pupa state is passed within the gallery. The moth differs greatly in appearance from the other two species, the fore wings being black from the base to near the middle, and white beyond. It expands from $\frac{1}{2}$ an inch to one inch.

Family PSYCHIDÆ

The Bag-worm Moths

The bag-worm moths are so called on account of the silken sacs made by the larvæ, in which they live and in which they change to pupæ. In our more conspicuous and best-known species the sac is covered either with little twigs (Fig. 347) or, in the case of a species that feeds on cedar or arbor-vitæ, with bits of leaves of these plants. When the larva is full-grown it fastens its sac to a twig and transforms within it.

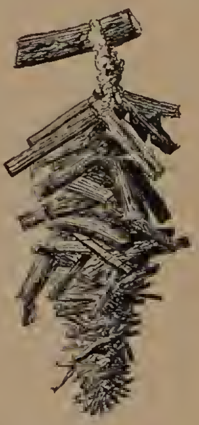

FIG. 347. — Bag of *Oiketicus abboti.*

In the adult state the two sexes differ greatly. The female is wingless, and in some genera the eyes, antennæ, mouth-parts, and legs are vestigial or wanting, the body being quite maggot-like. At the caudal end of the body there is a tuft of hair-like scales which are mixed with the eggs. In most species the female does not leave the sac before oviposition but deposits her eggs within it.

The male moths are winged; they are small or of moderate size. The wings are thinly scaled and in some species nearly naked; when clothed with scales they are usually of a smoky color without markings. The venation of the wings varies greatly within the family. Figure 348 represents the venation of our most common species.

Only about twenty species are known from our fauna, of which the following are most likely to be observed.

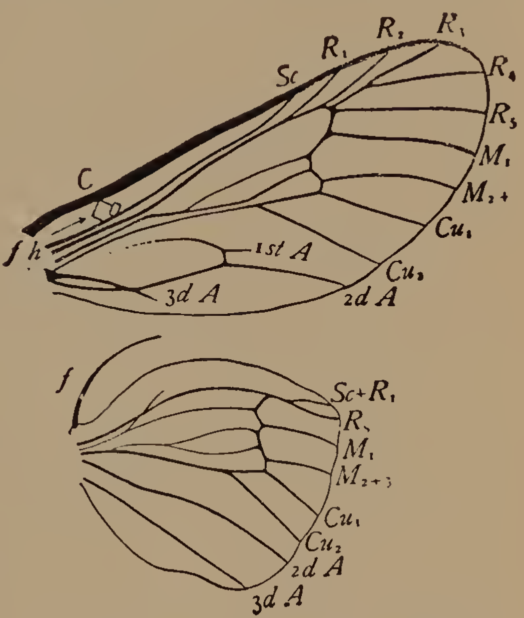

Fig. 348. — Wings of *Thyridopteryx ephemeræformis.*

Abbot's bag-worm, *Oikĕticus abbŏti.* — This species occurs in the more southern part of our country. The larva makes a bag with sticks attached to it crosswise (Fig. 347). The adult male is sable brown, with a vitreous bar at the extremity of the discal cell of the fore wings; the narrow external edging of the wings is pale; the expanse of the wings is $1\frac{1}{3}$ inches.

The evergreen bag-worm, *Thyridŏpteryx ephemeræfŏrmis.* — This species prefers red cedar and arbor-vitæ, and for this reason has been named the evergreen bag-worm; but it also feeds on many other kinds of trees, and as it is the species that is most likely to attract attention, and is sometimes a serious pest, it is often called the bag-worm. It is our best-known species, and its life-history will serve as an illustration of the habits of the members of the family Psychidæ.

The bag of this species is about the same size as that of Abbot's bag-worm (Fig. 347); but differs in being covered with sprays of leaves when it feeds on cedar or arbor-vitæ, or with twigs attached lengthwise when it feeds on other trees. When full-grown the larva fastens the bag to a twig with a band of silk, and then changes to a pupa. When the male is ready to emerge, the pupa works its way to the lower end of the bag and half-way out of the opening at the extremity. Then its skin bursts and the adult emerges. The male moth has a black, hairy body and nearly naked wings (Fig. 349). The adult female only partly emerges from the pupa skin and awaits the approach of the male. She is entirely destitute of wings and legs. The abdomen of the male can be greatly extended, making possible the pairing while the female is still in the bag. After pairing, the female works her way back into the pupa skin, where she deposits her eggs mixed with the hair-like scales from the end of her

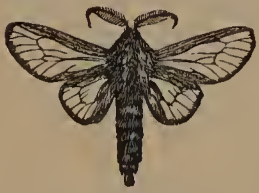

Fig. 349. — *Thyridopteryx ephemeræformis.*

body. She then works her shrunken body out of the bag, drops to the ground, and perishes. The eggs remain in the pupa skin in the sac till the following spring.

Family TISCHERIIDÆ

Nearly all of our species belong to the genus, *Tischeria*. The end of each narrow front wing is prolonged into a point; the hind wings are long and narrow with few veins. The larvæ lack thoracic legs and most of them make blotch mines in the leaves of oak; but some infest the apple, blackberry, and raspberry.

The trumpet-leaf miner of apple, *Tischēria malifoliĕlla.* — This species infests the leaves of apple over the eastern half of the United States and Canada, and sometimes does serious injury. The larva makes a trumpet-shaped mine just beneath the epidermis on the upper side of the leaf; the first half of the mine is usually crossed by crescent-shaped stripes of white. There are two generations annually in the North, and several in the South. The larvæ pupate in their mines. The larvæ of the last generation line their mines with silk and pass the winter in them. They transform to pupæ in the spring and emerge as adults eight or ten days later. The adult moth expands about $\frac{1}{4}$ of an inch; it has shining dark brown front wings, tinged with purplish and dusted with pale yellowish scales.

Family LYONETIIDÆ

These are small moths with very narrow wings, the hind wings often linear. The larvæ are leaf-miners at first and then usually feed on the surface of the foliage.

The morning-glory leaf-miner, *Bedĕllia somnulentĕlla.* — The young larva makes a serpentine mine with a central line of frass; later it leaves this mine and makes a blotch mine. The pupa is naked, and fixed by the caudal end to some cross-threads on the underside of the leaf. The adult is yellow and expands about $\frac{2}{5}$ of an inch.

The apple bucculatrix, *Bucculātrix pomifoliĕlla.* — The larva of this species infests the leaves of apple, and when full-grown it makes a small white cocoon which is attached to the lower surface of a twig. These cocoons sometimes occur in great numbers, side by side, on the twigs of an infested tree (Fig. 350). They are easily recognized by their shape, being slender and ribbed lengthwise. It is these cocoons that usually first reveal the presence of the pest in an orchard. They are very conspicuous during the winter, when the leaves are off the trees. At this time each cocoon contains a pupa. The adult moth emerges in early spring. The eggs are laid on the lower surface of the leaves. The tiny caterpillar burrows into the leaf and mines in it for about eight days. It then comes out and feeds openly on the leaf for the rest of its life.

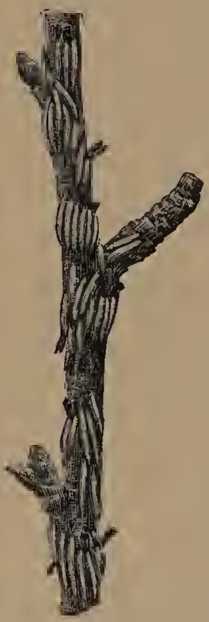

FIG. 350. — Cocoons of *Bucculatrix pomifoliella.*

Family Gracilariidæ

The vestiture of the head varies greatly; the vertex is clothed with prominent scales in some forms, in others it is smooth. The antennæ are long. The fore wings are lanceolate, normal or with somewhat reduced venation (Fig. 351). The hind wings are lanceolate or linear.

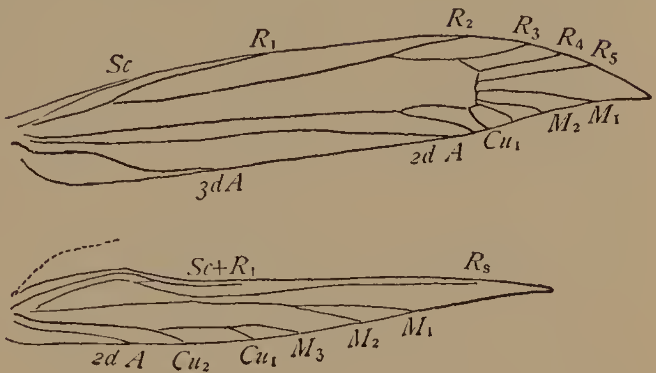

Fig. 351. — Wings of *Gracilaria*. (After Spuler.)

The adult moths when at rest elevate the front part of the body, the fore legs being held vertically so that the tips of the wings touch the surface on which the insect rests.

The larvæ are extraordinary; when young they are very much flattened and have thin, blade-like mandibles and vestigial maxillæ and labium; they merely slash open the cells of the leaf and suck up the cell-sap; later they usually have normal mouth-parts and eat the parenchyma. The young larvæ always make a flat blotch mine; later many make a blotch mine in which the epidermis of one side of the leaf is thrown into a fold by the growth of the leaf, *i.e.*, a *tentiform mine*, or they roll a leaf. The larvæ have only fourteen legs or none, never any on the sixth segment of the abdomen.

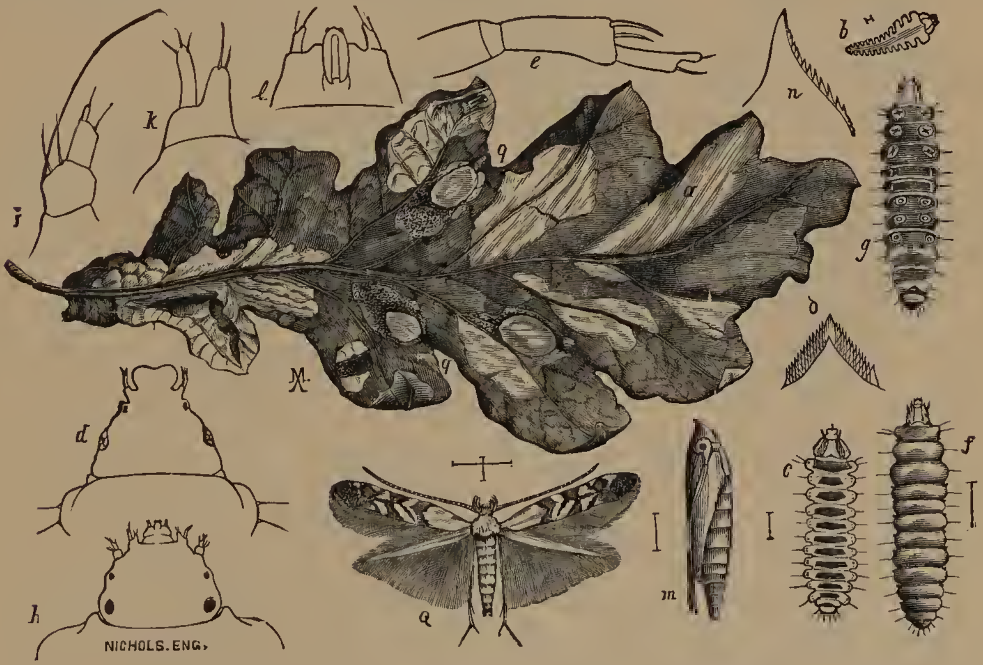

Fig. 352. — *Phyllonorycter hamadryadella:* *a*, mine; *b*, young larva; *c*, full-grown, flat-form larva; *d*, head of same, enlarged; *e*, antenna of same, enlarged; *f*, round-form larva from above; *g*, same from below; *h*, head of same, enlarged; *i*, antenna of same, enlarged; *k*, maxilla and palpus of same, enlarged; *l*, labium, labial palpi, and spinnerets of same; *m*, pupa; *n*, side view of pupal crest; *o*, front view of same; *q*, cocoon; *Q*, moth.

This is a large family; about two hundred North American species have been described.

The white-blotch oak-leaf miner, *Phyllonorÿcter hamadryadĕlla.* — This little miner infests the leaves of many different species of oaks, and is very common throughout the Atlantic States. The mine is a whitish blotch mine in the upper side of the leaf, and contains a single larva; but often a single leaf contains many of these mines (Fig. 352). The young larva is remarkable in resembling more the larva of a beetle than the ordinary type of lepidopterous larvæ (Fig. 352, *b*). It is nearly flat; the first thoracic segment is much larger than any of the others; the body tapers towards the hind end; and there are only the faintest rudiments of legs discernible. The larvæ molt seven times. At the seventh molt the form of the body undergoes a striking change. It now becomes cylindrical in form, and the fourteen feet are well developed. It spins a cocoon, which is simply a delicate, semitransparent, circular sheet of white silk, stretched over a part of the floor of the mine. The pupa is dark brown in color, and bears a toothed crest upon its head (Fig. 352, *n*, *o*). The moth is a delicate little creature, whose wings expand a little more than $\frac{1}{4}$ of an inch.

Family COLEOPHORIDÆ

Moths with a smooth head, without ocelli, and without maxillary palpi. The labial palpi are of moderate size. The antennæ are held extended forward in repose. The wings are very narrow.

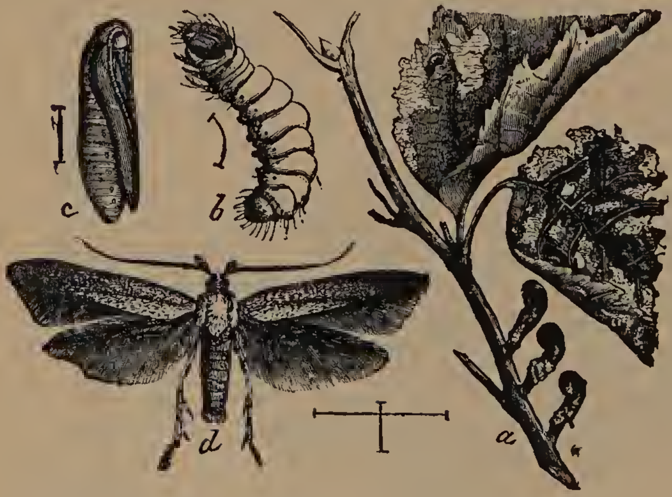

FIG. 353. — *Coleophora malivorella:* *a*, apple twig showing larval cases and work on leaves; *b*, larva; *c*, pupa; *d*, moth; *b*, *c*, *d*, enlarged. (After Riley.)

The larvæ are usually leaf-miners when young or feed within seeds; later, with few exceptions, they are case-bearers.

All of our species belong to the genus *Coleophora*, of which about ninety species have been found in this country. The two following species are those that have attracted most attention on account of their economic importance.

The pistol case-bearer, *Coleŏphora malivorĕlla.* — The larva of this species infests apple especially but is also found on quince, plum, and cherry. The larvæ hatch in mid-summer from eggs laid on the leaves and eat little holes in the leaves. They soon construct little pistol-shaped cases composed of silk, the pubescence of leaves, and excrement (Fig. 353). The larva projects itself out from the case far enough to get a foothold and eats irregular holes in the leaf, holding the case at a considerable angle with the leaf. About September first the larvæ migrate to the twigs where they fasten the cases to the bark and hibernate till April.

The cigar case-bearer, *Coleŏphora fletcherĕlla.* — This species, like the preceding one, is a pest of apple and other fruit trees, and resembles that species to a considerable extent in habits. In this species the young larvæ are miners in the leaves for two or three weeks before making their cases. The case (Fig. 354) is composed of fragments of leaves fastened together by silk.

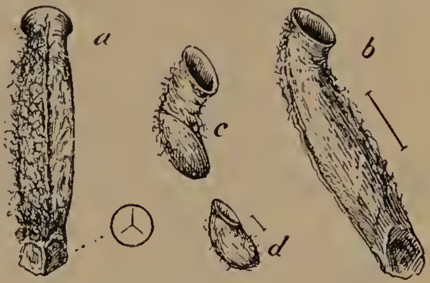

Fig. 354. — Cases of cigar case-bearer. (After Hammar.)

Family Œcophoridæ

The wings of these moths are fairly broad, sometimes amply so. The labial palpi are well-developed and generally curved upward.

The larvæ have sixteen legs; they are often prettily marked with dark tubercles on whitish or yellowish ground. The different species vary in their habits; the majority of them either live in webbed-together leaves or blossoms or feed in decayed wood; one species, *Ĕndrosis lacteĕlla,* is a stored-food pest in California and in Europe.

The parsnip webworm, *Depressāria heracliāna,* is a common pest on parsnip. The larvæ of this species web together and devour the unfolding blossom-heads of parsnip, celery, and wild carrot. After the larvæ have consumed the flowers and unripe seeds and become nearly full-grown, they burrow into the hollow stems and feed upon the soft lining of the interior. Here inside the hollow stem they change to pupæ. The moths appear in late July and early August, and soon go into hibernation in sheltered places.

Family Gelechiidæ

This is a very large family of small moths.

The larvæ vary greatly in habits; some are leaf-miners; but more feed in rolled or spun together leaves or in stems or seed heads; and one is a serious pest of stored grain.

The Angoumois grain-moth, *Sitōtroga cerealĕlla.* — The larva of this moth feeds upon seeds, and especially upon stored grain. It occurs throughout our country; but it is especially destructive in the Southern States. In that part of the country it is extremely difficult to keep grain long on account of this pest and certain beetles that also feed on stored grain. The adult moth is of a very light grayish-brown color, more or less spotted with black; it expands about ½ inch. The common name is derived from the fact that it has been very destructive in the province of Angoumois, France.

The peach twig-borer, *Anărsia lineatĕlla.* — This pest is generally distributed throughout the United States and Canada, and sometimes it destroys a large part of the crop in some localities. The young larvæ hibernate in small cavities which they excavate in the bark of young twigs. In the spring the larvæ burrow into the tender shoots; the leaves of the buds unfold and then wither. There are several generations annually. The summer generations attack both twigs and fruit.

The potato-tuber moth, *Phthorimæa opĕrculĕlla.* — This is a cosmopolitan insect injurious to the tomato, potato, egg-plant and tobacco. On the latter plant the larva is known as the tobacco splitworm.

The adult is a small moth with the front wings mottled with black and ochre and expanding a little over one-half an inch. The larva is white often with a pinkish cast on the back and about $\frac{2}{5}$ of an inch long. There are several generations a year.

The solidago gall-moth, *Gnorimoschēma gallæsolidăginis.* — There are two kinds of conspicuous galls which are enlargements of the stems of goldenrod; one of these is a ball-like enlargement of the stem and is caused by the larva of a fly, *Eurosta solidaginis*, described in the next chapter; the other is spindle-shaped and is caused by the moth named above. The eggs are laid on the old plants in the fall and hatch in spring. The young larva crawls to a new shoot and boring down into it causes the growth of the gall (Fig. 355).

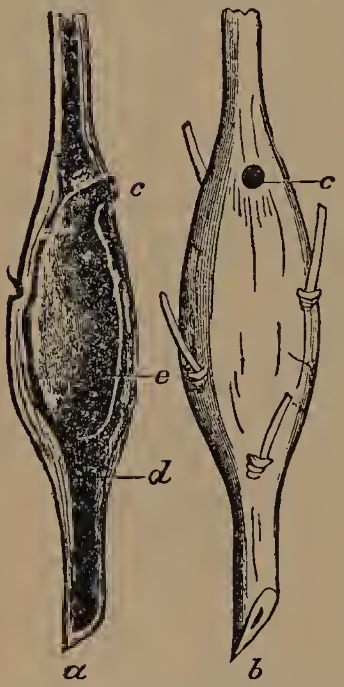

Fig. 355. — Gall of the solidago gall-moth. (After Riley.)

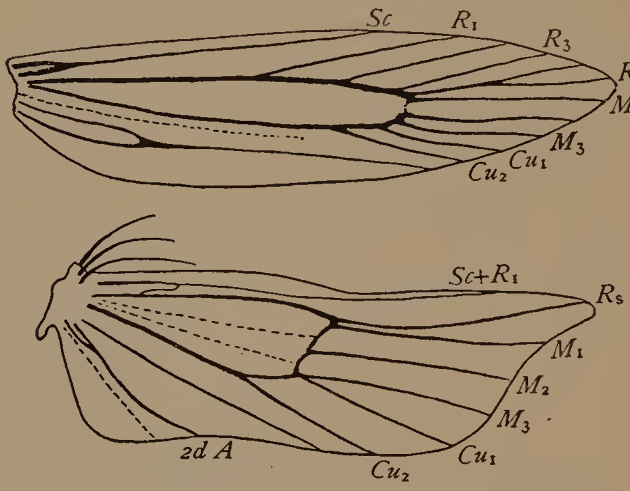

Fig. 356. — Wings of *Pectinophora gossypiella.* (After Busck.)

The pink bollworm, *Pectinŏphora gossypiĕlla.* — This species is regarded as one of the most destructive cotton insects known and ranks among the half-dozen most important insect pests of the world. It often reduces the yield of lint fifty per cent. or more and materially lessens the amount of oil obtained from the seeds.

The adult is a small dark-brown moth, with a wing-expanse of from $\frac{3}{5}$ to $\frac{4}{5}$ of an inch. Figure 356 represents the shape and the venation of the wings. The larva eats the seeds and tunnels and soils the lint, causing the arrest of growth and the rotting or premature and imperfect opening of the boll (Busck).

The burdock moth, *Metznĕria lappella.* — The stout white legless caterpillar of this moth is common in the burs of burdock into which it mines and eats out the seeds. It winters in the burs and transforms to the moth in June and July. The moth is of a dull olive brown with paler yellowish shades and streaks on the front wings. It expands from $\frac{1}{2}$ to $\frac{3}{5}$ of an inch.

Family YPONOMEUTIDÆ

This is not a large family but it contains several species of economic importance among which is the cedar tineid, *Argyrĕsthia thuiĕlla*, the larvæ of which feed on the leaves of cedar, the apple-fruit miner *Argyrĕsthia conjugĕlla*, the larvæ of which burrow in all directions in the fruit causing it to decay, the ermine moths and the ailanthus webworm.

The ailanthus webworm, *Attēva punctella.* — The larvæ live in communities in a slight silken web on the Ailanthus; they feed on the leaves and also gnaw the leaf-stalks in two. When the larva is full-grown it suspends itself in the middle of a loose web and transforms there. The adults appear in September and October and pass the winter in this state. The adult is very striking in appearance. The fore wings are bright marigold-yellow with four bands of round pale sulphur-yellow spots upon a brilliant steel-blue ground. The hind wings are transparent, with a dusky margin and blackish veins. The wing-expanse is about 1 inch.

The ermine-moths, *Yponomeŭta.* — There are several species of the typical genus of this family that have received the common name ermine-moths, because of the color of their fore wings, which are snowy white dotted with black. One of these, *Yponomeŭta padĕlla*, is an introduced species which is an apple and cherry pest. The larvæ live in a common web, and in this they spin their cocoons.

The name ermine-moths is applied also, especially in England, to some of the Arctiidæ that are white spotted with black.

Family ÆGERIIDÆ

The Clear-winged Moths

The clear-winged moths constitute a very remarkable family, many of them resembling bees or wasps in appearance more than they do ordinary moths, a resemblance due to their clear wings and in some cases to their bright colors (Fig. 357). There are a few moths in other families, that have a greater or less part of the wings devoid of scales; but they are exceptions. Here it is the rule that the greater part of one or both pairs of wings are free from scales. In a small number of members of this family the wings are scaled throughout and the wings are held together by hamuli.

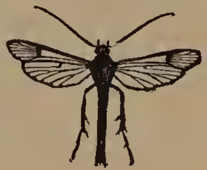

FIG. 357.

These insects are of moderate size; as a rule they have spindle-shaped antennæ, which are terminated by a small silky tuft; sometimes the antennæ are pectinate; the margins of the wings and the veins of even the clear-winged species are clothed with scales; and at the end of the abdomen there is a fan-like tuft of scales.

The fore wings are remarkable for their extreme narrowness and the great reduction of the anal area (Fig. 358); while the hind wings have a widely expanded anal area. The number of anal veins in the hind wings varies greatly within the family, the number ranging from two to four.

Another remarkable feature of the wings of these insects is that in the female the bristles composing the frenulum are consolidated as in the male; this condition exists in the females of a few members of other families. The females of the Ægeriidæ possess a frenulum hook; but this is not so highly specialized as that of the male.

The adults fly very swiftly and during the hotter part of the day. They frequent flowers thus increasing their resemblance to bees or to wasps. The larvæ are borers, living within the more solid parts of plants. Some species cause serious injury to cultivated plants. More than one hundred species have been found in America north of Mexico. Among the better known species are the following.

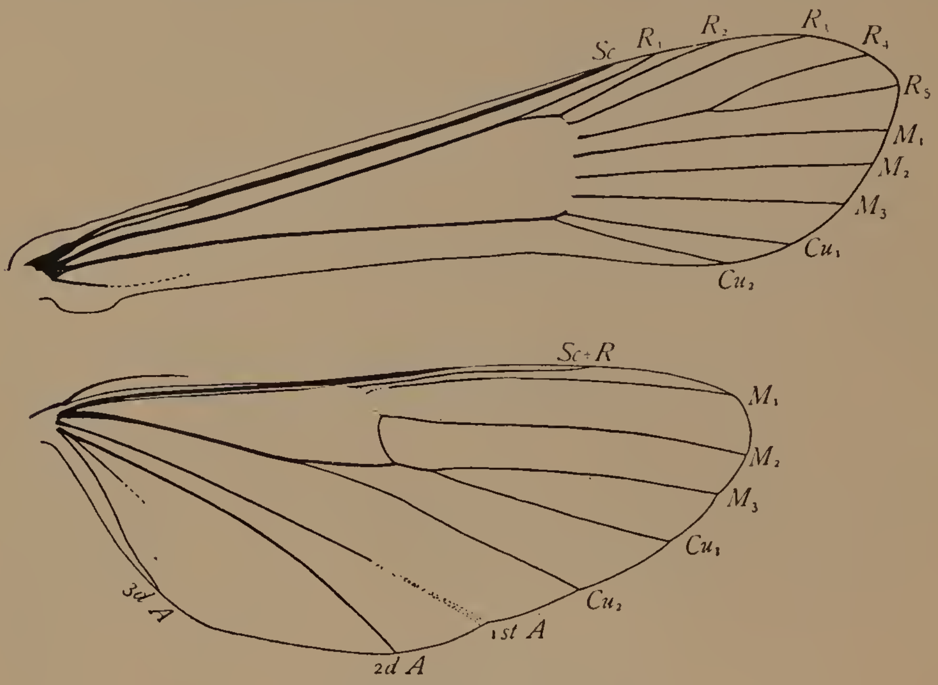

Fig. 358. — Wings of *Synanthedon exitiosa.*

The blackberry-crown borer or the raspberry-root borer, *Bembēcia margināta.* — The larva of this species burrows in the roots and lower part of the canes of blackberries and raspberries, sometimes completely girdling the cane at the crown.

The peach-tree borer, *Synanthedon exitiōsa.* — This is one of the most important enemies of the peach-tree. The eggs are laid on the bark of the tree near the ground. The larvæ burrow in the inner bark and sapwood just below the surface of the ground. Their injuries cause the tree to exude large masses of gum which collect around the base of the trunk. The insect passes the winter as a larva and in the spring makes a long cocoon at the surface of the ground. The moths appear from May to October.

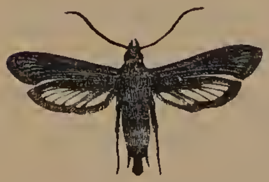

Fig. 359. — *Synanthedon exitiosa,* female.

The steel-blue female moth has (Fig. 359) the fore wings covered with scales, and there is a bright orange-colored band on the abdomen. In the male both pairs of wings are nearly free from scales.

The Pacific peach-tree borer, *Synănthedon opalĕscens.* — On the Pacific Coast there is a peach-tree borer that is distinct from the above, and appears to be an even more serious pest. The larva is more difficult to remove from the tree, as it bores into the solid wood. The female of this species lacks the orange-colored band on the abdomen.

The lesser peach-tree borer, *Synănthedon pĭctipes.* — The larvæ of this species infest peach, plum, cherry, june-berry, beach-plum, and chestnut. They do not confine their attacks to the crown but more often occur on the trunk and larger branches. Both sexes of the adult resemble the male of the peach-tree borer, having both fore and hind wings transparent.

The imported currant borer, *Chamæsphēcia tipulifŏrmis.* — This is a small species, the adult having a wing-expanse of only about $\frac{7}{10}$ of an inch. There are but few scales on either pair of wings except on the tip and discal vein of the fore wings and the outer margin of the hind wings. The eggs are laid on the twigs of currant. The larvæ penetrate the stem, and make a burrow in which they live and undergo their transformations.

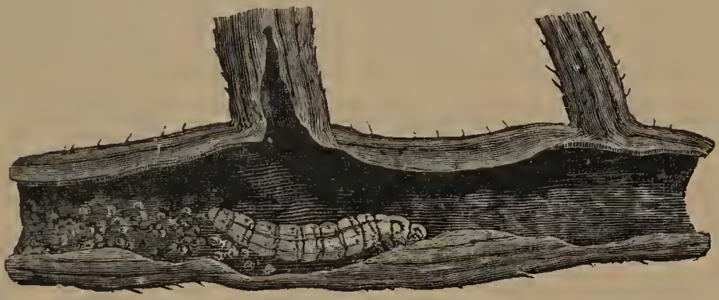

FIG. 360. — *Melittia satyriniformis*, larva in squash-vine.

The squash-vine borer, *Melĭttia satyrinifŏrmis.* — The larva of this species (Fig. 360) does great damage by eating the interior of squash-vines; it also sometimes infests pumpkin-vines and those of cucumber and melon. It is most destructive to late squashes. When full-grown the larvæ leave the vines and enter the ground, where they make tough silken cocoons, a short distance below the surface, in which the winter is passed. The adults appear soon after their food-plants start growth. The fore wings of the adult are covered with scales and the hind legs are fringed with long, orange-colored scales.

The pine clear-wing moth, *Parharmŏnia pīni.* — Frequently there may be seen on the trunks of pine-trees large masses of resinous gum mingled with sawdust-like matter. These are the results of the work of the larvæ of this insect, which bore under the bark and into the superficial layers of the wood. The adult resembles the female of the peach-tree borer, but the abdomen is more extensively marked with orange beneath.

Family TORTRICIDÆ

The Tortricids

The so-called tortricid moths in the wider sense, include three families of mostly small moths of which about 800 species from North America have been described. They have broad front wings which usually end squarely (Fig. 361). The costal margin of each front wing curves forward strongly near the base of the wing. When the moths are at rest the front wings fold above the body like a roof.

The larvæ vary greatly in habits. Many of them are leaf-rollers.

It was this habit that suggested the name *Tortrix* for the typical genus, from which the name of this family is derived. A large portion of the rolled leaves found upon shrubs and trees are homes of tortricid larvæ; but it should be remembered that the leaf-rolling habit is not confined to this family. While many are leaf-rollers probably a larger number are borers in stems, buds, or fruits.

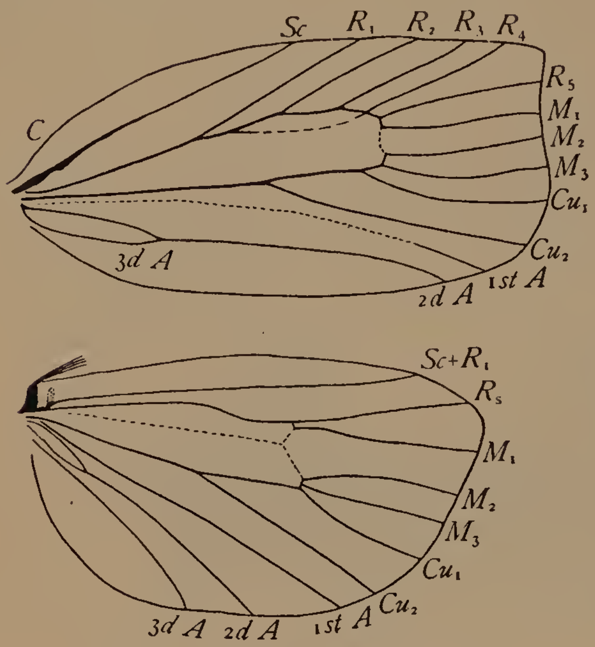

Fig. 361. — Wings of *Archips cerasivorana.*

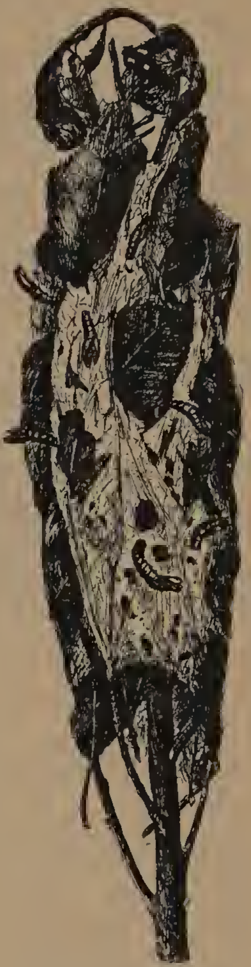

Fig. 362. — Nest of *Archips cerasivorana.*

Several of our better-known members of this family belong to the genus *Ărchips*. This is the genus *Cacœcia* of many authors. These insects have been named the ugly-nest tortricids; ugly dwelling being the meaning of *Cacœcia*, and also descriptive of the nests of the larvæ of these insects. The four following species are common.

The oblique-banded leaf-roller, *Ărchips rosaceāna.* — The larva of this moth feeds within the rolled and webbed-together leaves of apple, pear, cherry, plum, and other fruits. The larva is light yellowish-brown to apple-green in color and about ¾ of an inch in length. The moth expands about one inch. It is cinnamon-brown in color and each front wing is crossed by three oblique bands.

The cherry-tree ugly-nest tortricid, *Ărchips cerasivorāna.* — This species lives upon the choke-cherry and sometimes upon the cultivated cherry. The larvæ, which are yellow, active creatures, fasten together all the leaves and twigs of a branch and feed upon them (Fig. 362), an entire brood occupying a single nest. The larvæ change to pupæ within the nest; and the pupæ, when about to transform, work their way out and hang suspended from the outer portion of the nest. Here they transform, leaving the empty pupa skins projecting from the nest. The wings of the moths are bright ochre-yellow; the front pair marked with irregular brownish spots and numerous transverse bands of leaden blue (Fig. 363, female).

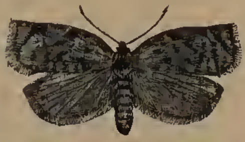
FIG. 363. — *Archips cerasivorana*, female.

The fruit-tree leaf-roller, *Archips argyrospīla.* — This is one of the most destructive of the leaf-rollers infesting fruit-trees. It is a very general feeder attacking both fruit and forest-trees. The eggs are laid on the bark of the twigs in June. The larvæ hatch about May 1st of the following year and enter the opening buds, where they roll and fasten the leaves loosely together with silken threads. After the fruits set, they are often ruined by the caterpillars eating large irregular holes in them.

The pine-leaf tube-builder, *Eulia pinatubāna.* — One of the most interesting of tortricid nests occurs commonly on white pine. Each nest consists of from six to fifteen leaves drawn together so as to form a tube, and is lined with silk. This tube serves as a protection to the larva, which comes out from it to feed upon the ends of the leaves of which the tube is composed; in this way the tube is shortened. The moth expands ½ inch. Its head, thorax, and fore wings are of a dull rust-red color, with two oblique paler bands crossing the fore wings, one a little before the middle, the other a little beyond and parallel with it.

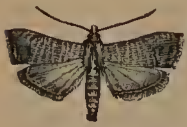
FIG. 364. — *Carpocapsa pomonella.*

The codling-moth, *Carpocăpsa pomonĕlla.* — This is the best known and probably the most important insect enemy of the apple. The larva is the worm found feeding near the core of wormy apples. The adult (Fig. 364) is a beautiful little creature with finely mottled pale gray fore wings. There is a large brownish spot near the end of the fore wing, and upon this spot irregular, golden bands. The moth issues from the pupa state in late spring and lays its eggs singly on the surface of the fruit or on adjacent leaves. As soon as the larva hatches it burrows into the apple and eats its way to the core, usually causing the fruit to fall prematurely. When full-grown the larva burrows out through the side of the fruit, and undergoes its transformations within a cocoon, under the rough bark of the tree, or in some other protected place. The larvæ winter in their cocoons transforming to pupæ during early spring.

The bud-moth, *Tmetŏcera ocellāna.* — The larva of this insect is a pest infesting apple-trees. It works in opening fruit-buds and leaf-buds, often eating into them, especially the terminal ones, so that all new growth is stopped. It also ties the young leaves at the end of a shoot together and lives within the cluster thus formed, adding other leaves when more food is needed. Sometimes so large a proportion of the fruit-buds are destroyed as to seriously reduce the amount of the crop. The pupa state is passed within the cluster of tied leaves or within a tube formed by rolling up one side of a leaf, and lasts about ten days. The moth expands about ⅗ of an inch; it is of a dark ashen gray, with a large, irregular, whitish band on the fore wing.

The grape-berry moth, *Polychrōsis viteāna.* — The larva of this moth causes wormy grapes. The moth emerges in the spring from its cocoon on a fallen leaf where it passed the winter. The first generation larvæ feed upon the embryo grapes. When full-grown, the larva passes to a leaf and makes a very peculiar cocoon. It cuts a semicircular incision in the leaf, bends over the flap thus made, fastens its free edge to the leaf, and lines the cavity thus enclosed with silk; here it transforms to a pupa. The moths of the second and later generations lay their eggs on the berries, and the larvæ bore into them and feed upon the pulp and seeds.

The oriental fruit-moth, *Laspeyrēsia molĕsta.* — This insect was discovered here in 1916. It has now spread over most of the eastern half of the United States. It attacks plum, cherry, peach, quince and apple. The pinkish-white larvæ which are slightly over one-half inch in length, bore into the tender shoots in spring and kill them. Later, they burrow into the fruits causing the latter to decay.

The moth is dark grayish-brown with a wing-expanse of about one-half an inch. The winter is passed as a full-grown larva and as a pupa beneath flakes of bark on the tree and under objects on the ground. There are several generations during a season.

The European pine-shoot moth, *Evĕtria buoliāna.* — It was discovered here in 1914. The dark brown larva, about ¾ of an inch long, eats into the terminal buds and burrows in the new shoots of pines. The moth is brightly colored with reddish-orange front wings suffused with dark red and crossed by several irregular silvery lines. It expands about ¾ of an inch.

Family PYRALIDIDÆ

The Py̆ralids

The members of this family found in our fauna are mostly small moths, but a few are of moderate size. So large a portion of the species are small that the family has been commonly classed with the preceding families as Microlepidoptera. The members of this family differ so greatly in appearance that it is not possible to give a general description that will serve to distinguish it; a very large portion of the species have a special look, due to their thin and ample hind wings with large anal areas (Fig. 365).

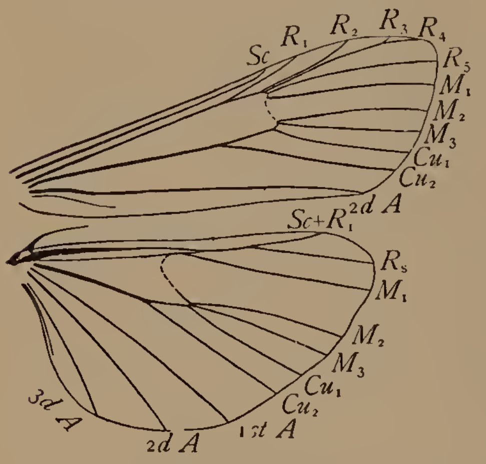

FIG. 365. — Wings of *Nomophila noctuella.*

The body is slender; the head is prominent; the ocelli are usually present; the antennæ are almost always simple; and the palpi are usually moderate in size or long; but very often they project beak-like; for this reason the name snout-moths is often applied to this family.

This is one of the larger families of the Lepidoptera; nearly one thousand species have been described from America north of Mexico alone. The family is divided into many subfamilies, representatives of fifteen of which are found in our fauna. The best known species, those that have attracted attention on account of their economic importance because they attack fruits, vegetables, cereals, stored foods, certain forest-trees and even other insects, are the following:

The Pyraustids

This group of the pyralids is a large one and although it contains many small moths, it also contains a majority of the larger species of this family.

The grape leaf-folder, *Dĕsmia funerālis.* — This is a common species throughout the United States, the larva of which feeds on the leaves of grape. The larva folds the leaf by fastening two portions together by silken threads. When full-grown it changes to a pupa within the folded leaf. The moth is black with shining white spots. The male (Fig. 366) differs from the female in having a knot-like enlargement near the middle of each antenna. There is some variation in the size and shape of the white spots on the wings. In some specimens the white spot of the hind wings is separated into two or three spots. There are two generations of this species in the North and three or more in the South.

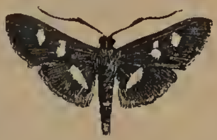
Fig. 366. — *Desmia funeralis.*

The basswood leaf-roller, *Pantŏgrapha limāta.* — Our basswood trees often present a strange appearance in late summer from the fact that nearly every leaf is cut more than half way across the middle, and the end rolled into a tube (Fig. 367). Within this tube there lives a bright green larva, with the head and thoracic shield black. When full grown the larva leaves this nest and makes a smaller and more simple nest, which is merely a fold of one edge of the leaf, or sometimes an incision is made in the leaf extending around about two-thirds of a circle and the free part bent over and fastened; in each case the nest is lined with silk, thus forming a delicate cocoon. Here the larvæ pass the winter in fallen leaves. The adult moth expands about $1\frac{1}{3}$ inches; it is straw-colored with many elaborate markings of olive with a purplish irridescence (Fig. 368).

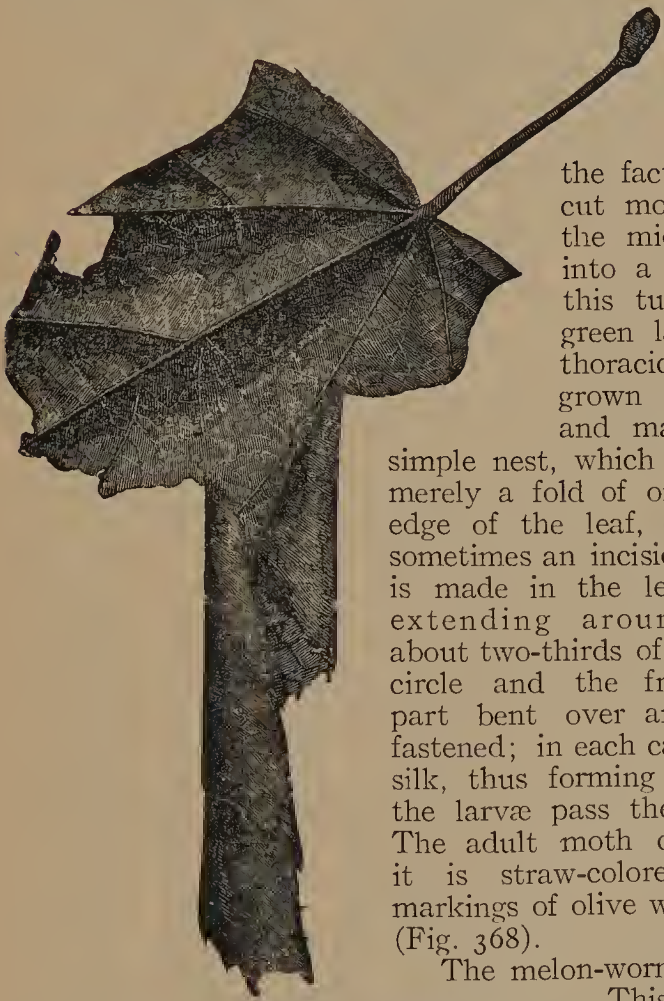
Fig. 367. — Nest of larva of *Pantographa limata.*

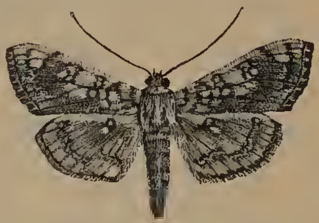
Fig. 368. — *Pantographa limata.*

The melon-worm, *Diaphānia hyalinātā.* — This beautiful moth (Fig. 369) is often a serious pest in our Southern States, where the larva is very destructive to melons and other allied plants. The young larvæ feed on the foliage; the older ones mine into the stems and fruit. The insect passes the winter as a pupa in loose silken cocoons in dead leaves or under rubbish. The moth is a superb creature, with glistening white wings bordered with black, and with a spreading brush of long scales at the end of the abdomen.

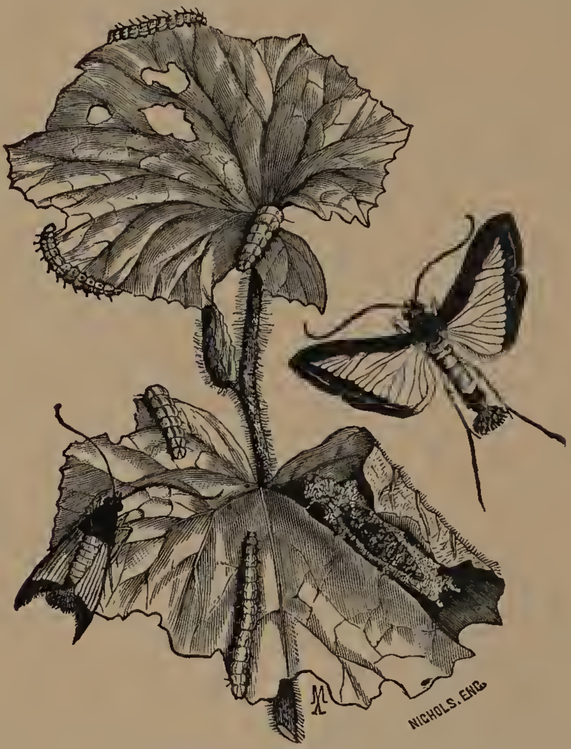
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FIG. 369. — *Diaphania hyalinata:* larvæ, cocoon, and adults.

The pickle-worm, *Diaphānia nitidālis.* — This species is closely allied to the preceding one. The wings of the moth are yellowish-brown with a purplish metallic reflection; a large irregular spot on the front wings and the basal two-thirds of the hind wings are semitransparent yellow. The tip of the abdomen is ornamented with a brush of long scales, as in the preceding species. The range and habits of this species are quite similar to those of the melon-worm.

The cabbage webworm, *Hĕllula undālis.* — This species infests various cruciferæ in the Gulf and South Atlantic States. The larva is about $\frac{1}{2}$ of an inch in length, of a grayish-yellow color, striped with five brownish-purple bands.

The garden webworm, *Loxŏstege similālis.* — This species is most injurious in the Southern States and in the Mississippi Valley. It infests various garden crops and corn and cotton. The larva varies in color from pale and greenish-yellow to dark yellow and is marked with numerous black tubercles.

The European corn-borer, *Pyrausta nubilālis.* — This is a greatly feared pest which has recently appeared in this country. It is a borer in the stems of plants, in which it winters as a partly grown larva. Its favorite food appears to be corn and especially sweet corn; but it infests other cultivated plants, as dahlias and gladiolus, and many large-stemmed weeds. The full-grown larva measures about $\frac{4}{5}$ of an inch in length; the adult moth has a wing-expanse of from 1 to $1\frac{1}{5}$ inches.

THE TYPICAL PYRALIDS

There are only about twenty-four species in this group and the two following are the best known.

The meal snout-moth, *Pȳralis farinālis.* — The larva of this species feeds on meal, flour, stored grain, and old clover hay. It makes little tubes composed partly of silk and partly of the fragments of its food. It rarely occurs in sufficient numbers to do serious injury; and its ravages can be checked by a thorough cleaning of the infested places, or when practicable by the use of carbon bisulphide. The moth is commonly found near the food of the larva, but is often seen on ceilings of rooms sitting with its tail curved over its back. It expands about 1 inch; the fore wings are light-brown, crossed by two curved white lines, and with a dark chocolate-brown spot on the base and tip of each.

The clover-hay worm, *Hypsopȳgia costālis.* — The larva of this species sometimes abounds in old stacks of clover hay, and especially near the bottom of such stacks. As the infested hay becomes covered with a silken web spun by the larva, and by its gunpowder-like excrement, much more is spoiled than is eaten by the insect. Such hay is useless and should be burned, in order to destroy the insects. The moth expands about $\frac{4}{5}$ of an inch. It is a beautiful lilac color, with golden bands and fringes (Fig. 370).

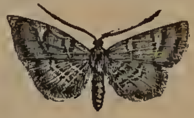


FIG. 370. — *Hypsopygia costalis.*

THE CLOSE-WINGS OR CRAMBIDS

This is not a large group but the members of it are more often seen than any other pyralids. The larvæ of most of the species feed on grass; and the adults fly up before us whenever we walk through meadows or pastures. When at rest, the moths wrap their wings closely about the body; this has suggested the name close-wings for the insects of this group. When one of these moths alights on a stalk of grass it quickly places its body parallel with the stalk, which renders it less conspicuous (Fig. 371). Many of the species are silvery-white or are marked with stripes of that color.

About seventy of our species belong to the genus *Crambus.* The moths of this genus are often seen; but the larvæ usually escape observation. They occur chiefly at or a little below the surface of the ground, where they live in tubular nests, constructed of bits of earth or vegetable matter fastened together with silk. Thus *Crămbus caliginosĕllus* is known as the corn-root webworm on account of its injury to young corn plants which it bores into and destroys; it is also known as the tobacco stalk-worm, on account of similar injury to young tobacco plants.

Another species, *Crămbus hortuĕllus*, is known as the cranberry girdler. It does considerable injury to cranberry vines by destroying the bark of the prostrate stems.

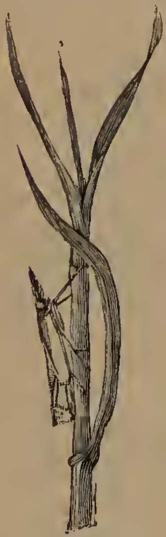


FIG. 371.— *Crambus.*

To this subfamily belong the larger corn-stalk borer, *Diatræa zeacolĕlla*, which sometimes bores into the stalks of young corn in the Southern States, and the sugar-cane borer, *Diatræa saccharālis*, which bores into the stalks of sugar-cane.

THE BEE-MOTH GROUP

This is a small subfamily of which only seven species have been found in our fauna. The best known of these is the bee-moth, *Gallēria mellonĕlla*. The larva of this species is a well-known pest in apiaries. It feeds upon wax; and makes silk-lined galleries in the honey-comb, thus destroying it. When-full grown the larva is about 1 inch in length. It lies hidden in its gallery during the day, and feeds only at night, when the tired-out bees are sleeping the sleep of the just. When ready to pupate the caterpillar spins a tough cocoon against the side of the hive.

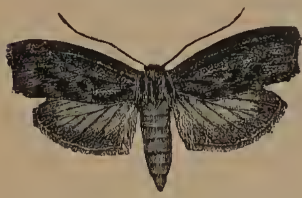


Fig. 372. — *Galleria mellonella.*

The moth has purplish-brown front wings, and brown or faded yellow hind wings. The fore wings of the male are deeply notched at the end, while those of the female (Fig. 372) are but slightly so. The female moth creeps into the hive at night to lay her eggs.

This pest is found most often in weak colonies of bees, which it frequently destroys. The best preventive of its injuries is to keep the colonies of bees strong. Of course the moths and larvæ should be destroyed whenever found.

THE PHYCITIDS

Our most common members of this subfamily are small moths with rather narrow but long fore wings, which are banded or mottled with shades of gray or brown. This is a very large subfamily; more than three hundred species have been described from our fauna, and there are doubtless many undescribed species in this country.

The larvæ of the different species vary greatly in habits. Some live in flowers, some fold or roll leaves within which they live and feed; some are borers; others feed upon dried fruits, or flour and meal; and one, at least, is predacious, feeding on coccids. Usually the larva lives in a silken tube or case, lying concealed by day and feeding by night. The case made by certain of the leaf-eating species is very characteristic in form (Fig. 373), being strongly tapering and much curved; in this instance the case is composed largely of the excrement of the larva.

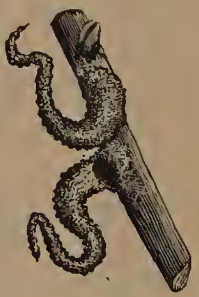


Fig. 373.

The following species are those that have attracted most attention on account of their economic importance.

The Indian-meal moth, *Plōdia interpunctĕlla.* — This is the best-known of the species that infest stored provisions. The larva is the small whitish worm, with a brownish-yellow head, that spins thin silken tubes through meal or among yeast-cakes or in bags or boxes of dried fruits. The moth expands about $\frac{3}{5}$ of an inch. The basal two-fifths of the fore wing is dull white or cream-colored; the outer part reddish-brown, with irregular bands of blackish scales.

The Mediterranean flour-moth, *Ephĕstia kuhniĕlla*, is an even more serious pest than the preceding species, which it resembles in habits. It has become very troublesome in recent years in flour-mills. The moth expands about 1 inch and is grayish in color.

Zimmermann's pine-pest, *Pinipĕstis zimmermănni*, is a common species, the larva of which is a borer. It infests the trunks of pine, causing large masses of gum to exude. The moths appear in mid-summer.

The coccid-eating pyralid, *Lætĭlia coccidĭvora*, differs from the other members of this family in being predacious. It feeds on the eggs and young of various scale-insects (*Pulvinaria*, *Dactylopius*, and *Lecanium*). Figure 374 represents the different stages of this insect enlarged, and the moths natural size resting on egg-sacs of *Pulvinaria*. Like other members of this family the larva spins a silken tube, within which it lives. On a thickly-infested branch these tubes may be found extending from the remains of one coccid to another.

To this subfamily belong also the gooseberry fruit worm, *Zophōdia grossulāriæ*, which feeds within the fruit of the gooseberry and currant, and the cranberry fruit worm, *Minēola vaccĭnii*, which bores into cranberry fruit.

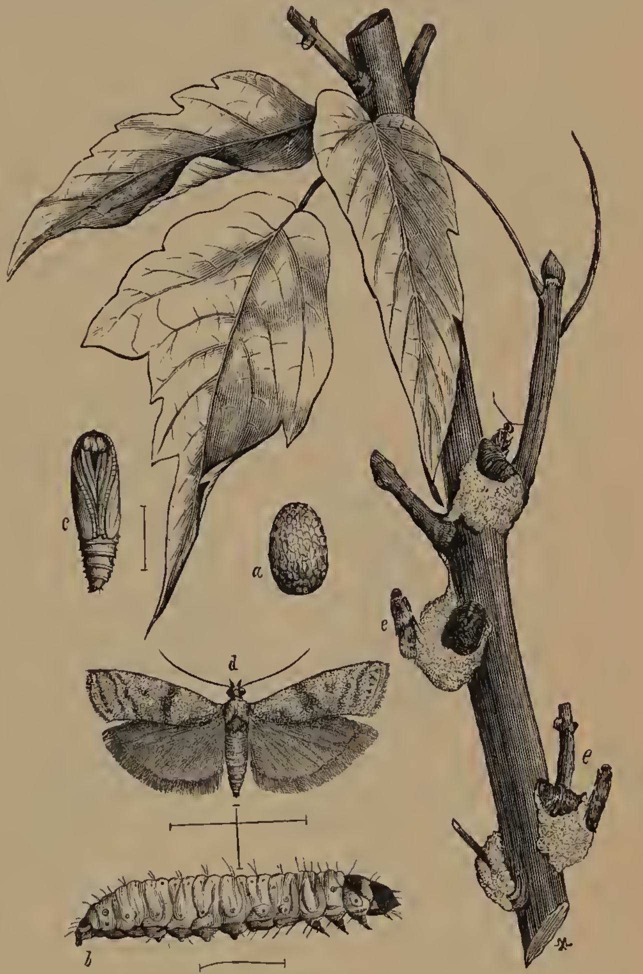


FIG. 374. — *Lætilia coccidivora: a*, egg; *b*, larva; *c*, pypa; *d*, adult; *e, e*, moths natural size, resting on egg-sacs of *Pulvinaria*.

Family PTEROPHORIDÆ

The Plume-moths

The plume-moths are so called on account of the remarkable form of the wings in most species; the wings being split by longitudinal fissures into more or less plume-like divisions. In most species each fore wing is separated into two parts, by a fissure extending about one-half the length of the wing; while each hind wing is divided into three parts by fissures extending farther towards the base of the wing.

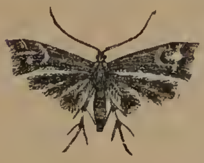


FIG. 375. — *Oxyptilus periscelidactylus*.

One of our most common species is the gartered plume, *Oxy̆ptilus periscelidăctylus*. This is a small moth, expanding about $\frac{3}{5}$ of an inch. It is of a yellowish-brown color marked with dull whitish streaks and spots (Fig. 375). The larvæ hatch early in the spring and feed upon the newly-expanded leaves of the grape. They fasten together several of them, usually those at the end of a shoot, with fine white silk; between the leaves thus folded the caterpillars live either singly or two or three together. They become full-grown and change to pupæ early in June. The pupa is not enclosed in a cocoon, but is fastened to the lower side of a leaf by its tail by means of a few silken threads, in nearly the same way as the chrysalids of certain butterflies are suspended. The pupa state lasts about eight days.

Family SPHINGIDÆ

The Hawk-moths or Sphinxes

Hawk-moths are easily recognized by the form of the body, wings and antennæ. The body is very stout and spindle-shaped; the wings are long, narrow and very strong; the antennæ are more or less thickened in the middle or towards the tip, which is frequently curved back in the form of a hook; rarely the antennæ are pectinated. The sucking-tube (maxillæ) is usually very long, being in some instances twice as long as the body; but in one subfamily it is short and membranous. When not in use it is closely coiled like a watch-spring beneath the head. None of the species has ocelli.

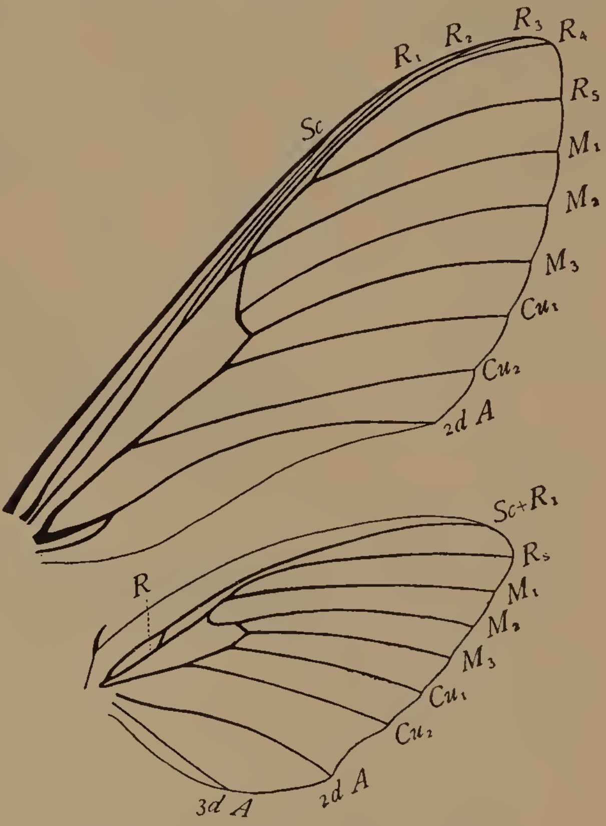


FIG. 376. — Wings of *Protoparce quinquemaculata.*

The venation of the wings (Fig. 376) is quite characteristic; the most distinctive feature is the prominence of the basal part of vein R_1 of the hind wing, the part that extends from the stem of radius to the subcosta. This free part of vein R_1 has the appearance of a cross-vein and is as stout as the other veins.

Some of the hawk-moths are small or of medium size; but most of them are large. They have the most powerful wings of all Lepidoptera in our fauna. As a rule they fly in the twilight, and have the habit of remaining poised over a flower while extracting the nectar, holding themselves in this position by a rapid motion of the wings. This attitude and the whir of the vibrating wings give them a strong resemblance to humming-birds, hence they are sometimes called humming-bird moths; but they are more often called hawk-moths, on account of their long, narrow wings and strong flight.

Of all the beautifully arrayed Lepidoptera some of the hawk-moths are the most truly elegant. There is a high-bred tailor-made air about their clear-cut wings, their closely fitted scales and their quiet but exquisite colors. The harmony of the combined hues of olive and tan, ochre and brown, black and yellow, and grays of every conceivable shade, with touches here and there of rose color, is a perpetual joy to the artistic eye.

The larvæ of the Sphingidæ feed upon leaves of various plants and trees and are often large and quite remarkable in appearance (Fig. 377). The body is cylindrical and naked and usually has a horn on the eighth abdominal segment. Sometimes instead of the horn there is a shiny tubercle or knob. We cannot even guess the use of this horn, unless it is ornamental, for it is never provided with a sting. These caterpillars when resting rear the front end of the body up in the air, curl the head down in the most majestic manner, and remain thus rigid and motionless for hours. When in this attitude they are supposed to resemble the Egyptian Sphinx, and so the typical genus was named *Sphinx* and the family the Sphingidæ.

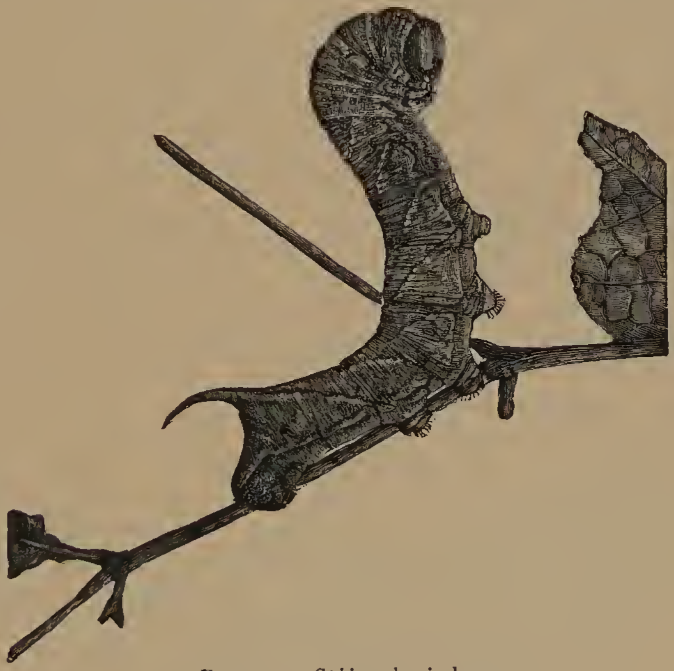


Fig. 377. — *Sphinx chersis*, larva.

Most species pass the pupa state in the ground in simple cells made in the earth; some, however, transform on the surface of the ground in imperfect cocoons composed of leaves fastened together with silk. One hundred species of hawk-moths occur in this country. The following are some of the more common ones.

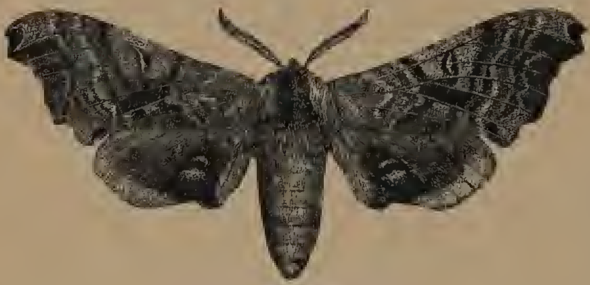


FIG. 378. — *Smerinthus geminatus.*

The twin-spotted sphinx, *Smerĭnthus geminātus.* — This exquisitely-colored moth expands about 2½ inches. The thorax is gray with a velvety dark brown spot in the middle. The fore wings are gray, with a faint rosy tint in some specimens, and tipped and banded with brown as shown in Figure 378. The hind wings are deep carmine at the middle, and are bordered with pale tan or gray. Near the anal angle there is a large black spot in which there is a pair of blue spots, which suggested the name *geminatus.* The larva feeds upon the leaves of apple, plum, elm, ash, and willow.

The pen-marked sphinx, *Sphinx chersis.* — This moth is of an almost evenly distributed ashy-gray color. This sombre color is relieved somewhat by a black band on each side of the abdomen, marked with four or five white transverse bars; by two dark brown, smoky bands which cross the hind wings; and by a series of black dashes on the fore wings, one in each cell between the apex of the wing and the anal vein. These dashes appear as if drawn casually with a pen. The larva is not uncommon upon ash and lilac; it is greenish or bluish-white above, and darker below; there are seven oblique yellow bands on the sides of the body, each edged above with dark green. When disturbed it assumes the threatening attitude shown in Figure 377.

The tomato-worm, *Protopărce quinquemaculāta.* — This larva is the best known of all our sphinxes, as it may be found feeding on the leaves of tomato, tobacco, or potato wherever these plants are grown in our country. It resembles in its general appearance the larva of *Sphinx chersis* (Fig. 377); but is stouter and has a series of pale longitudinal stripes low down on each side, in addition to the oblique stripes; and its favorite attitude is with the fore end of the body slightly raised. It is usually green, but individuals are often found that are brown, or even black. There appear at frequent intervals in the newspapers accounts of people being injured by a poison excreted by the caudal horn of this larva; but there is absolutely no foundation whatever for such stories. The pupa (Fig. 379) is often ploughed up in gardens, and attracts attention on account of its curious tongue-case a part of which is free resembling the handle of a pitcher. The moth is a superb creature, expanding four or five inches. It is of many delicate shades of ash-gray, marked with black or very dark gray; there are a few short black dashes on the fore part of the thorax, and some irregular black spots edged with white on the posterior part; the abdomen is gray with a black middle line, and five yellow, almost square spots along each side. Each

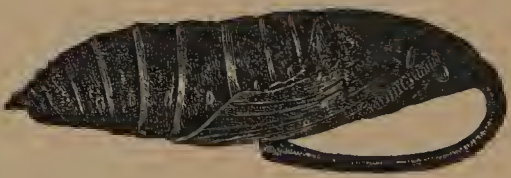


FIG. 379. — *Protoparce quinquemaculata*, pupa.

of these spots is bordered with black, and has a white spot above and below, on the edge of the segment. The hind wings are crossed by four blackish lines, of which the two intermediate are zigzag.

The tobacco-worm, *Protopărce sexta.* — This species closely resembles the preceding and the two are often mistaken the one for the other. The larvæ have similar habits, feeding on the same plants; but in this species the larva lacks the series of longitudinal stripes characteristic of the tomato-worm. The moths are easily distinguished; this species is brownish-gray instead of ashy-gray; at the end of the discal cell of the fore wings there is a distinct white spot; and the two dark bands crossing the middle of the hind wings are not zigzag, and are less distinctly separate; often they are united into a single broad band.

The hog-caterpillar of the vine, *Ampelœca myron.* — There is a group of hawk-moths the larvæ of which have the head and first two thoracic segments small, while the two following segments are greatly swollen. These larvæ from a fancied resemblance to fat swine have been termed hog-caterpillars; and the present species, which is common on grape, has been named the hog-caterpillar of the vine. It is a comparatively small species, the full-grown larva being but little more than 2 inches long. There is a row of seven spots varying in color from red to pale lilac, each set in a patch of pale yellow, along the middle of the back. A white stripe with dark green margins extends along the side from the head to the caudal horn, and below this are seven oblique stripes. This larva is often infested by braconid parasites; and it is a common occurrence to find one of them with the cocoons of the parasites attached to it (Fig. 380). The pupa state is passed on the surface of the ground within a rude cocoon made by fastening leaves together with loose silken threads. The adult expands about $2\frac{1}{5}$ inches. The fore wings are olive-gray, with a curved, olive-green, oblique band crossing the basal third, a discal point of the same color, and beyond this a large triangular spot with its apex on the costa and its base on the inner margin.

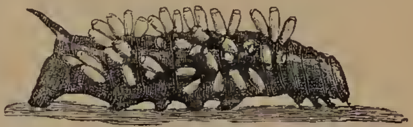


Fig. 380. — *Ampelœca myron*, larva with cocoons of parasites.

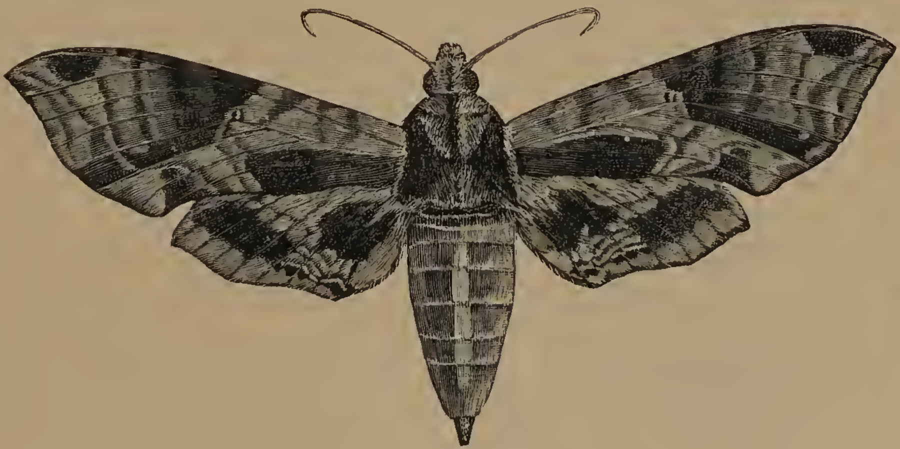


Fig. 381. — *Pholus pandorus.*

The pandorus sphinx, *Pholus pandōrus.* — This magnificent moth expands from 4 to 4½ inches. The ground color of its wings is pale olive, verging in some places into gray; the markings consist of patches and stripes of dark, rich velvety olive, sometimes almost black (Fig. 381). Near the inner margins of both pairs of wings the lighter color shades out into pale yellow, which is tinged in places with delicate rose-color. These markings show a harmony of contrasting shades rarely equalled elsewhere by nature or art. The larva is one of the hog-caterpillars. It feeds upon the leaves of Virginia-creeper. When young it is pinkish in color, and has a long caudal horn; as it matures it changes to a reddish-brown, and the horn shortens and curls up like a dog's tail and finally disappears, leaving an eye-like tubercle. The caterpillar has on each side five or six cream-colored oval spots, enveloping the spiracles.

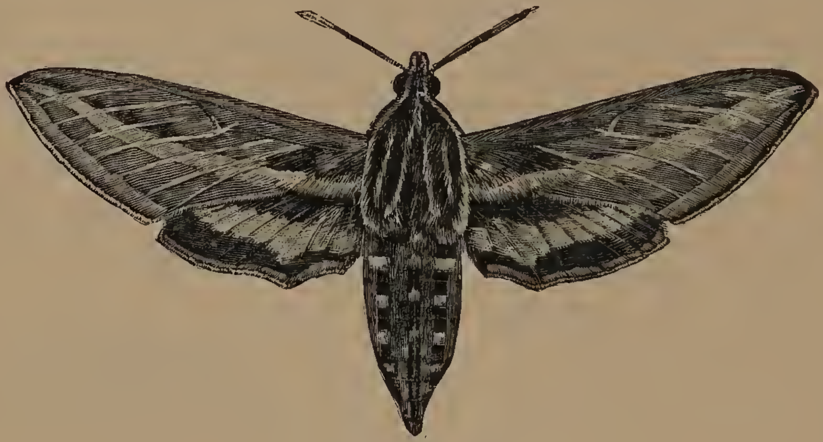


FIG. 382. — *Celerio lineata.*

The white-lined sphinx, *Celĕrio lineāta.* — This moth can be easily recognized by Figure 382. Its body and fore wings are olive-brown; there are three parallel white stripes along each side of the thorax; the outer one of these extends forward over the eyes to the base of the palpi; on the fore wings there is a buff stripe extending from near the base of the inner margin to the apex, and veins R_5 and 2d A are lined with white; the hind wings are black with a central reddish band. The larva is extremely variable in color and markings. It feeds on many plants, among which are apple, grape, plum, and currant.

The thysbe clear-wing, *Hæmorrhāgia thysbe.* — There is a group of hawk-moths that have the middle portion of the wings transparent, resembling in this respect the Ægeriidæ; but they are easily recognized as hawk-moths by the form of the body, wings, and antennæ. One of the more common of these is the thysbe clear-wing (Fig. 383). The scaled portions of the wings are of a dark reddish-brown; but this species is most easily distinguished from all our other species by a line of scales dividing the discal cell lengthwise and representing the position of the base of vein M. The larva of this species feeds on the different species of *Viburnum*, the snow-berry, and hawthorn.

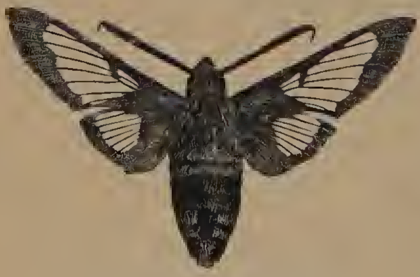


FIG. 383. — *Hæmorrhagia thysbe.*

Family Geometridæ

The Geometrids or the Measuring-worms

The family Geometridæ is composed of those moths the larvæ of which are known as measuring-worms, span-worms, or loopers. They progress by a series of looping movements. They first cling to the supporting twig or leaf by their thoracic legs; then arch up the back while they bring forward the hinder part of the body and seize the support, at a point near the thoracic legs, by the prolegs at the caudal end of the body; then, letting loose the thoracic legs (Fig. 384), they stretch the body forward, thus making a step; this process is then repeated.

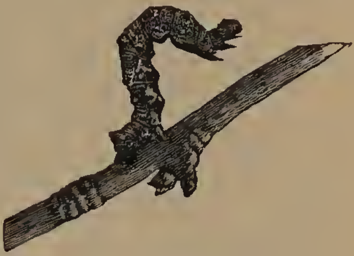


Fig. 384. — A measuring-worm.

The larvæ of geometrids have as a rule only the last two pairs of prolegs well developed; and hence, as the middle part of the body is not supported, they are unable to walk in the way that other caterpillars walk. It is probable, however, that the loss of the first three pairs of prolegs is the result of the looping gait rather than the cause of it.

Frequently measuring-worms when resting cling by their prolegs and hold the body out straight, stiff, and motionless, appearing like a twig; this is doubtless a protective resemblance.

The geometrid larvæ are leaf-feeders, and some species occur in such large numbers as to be serious pests.

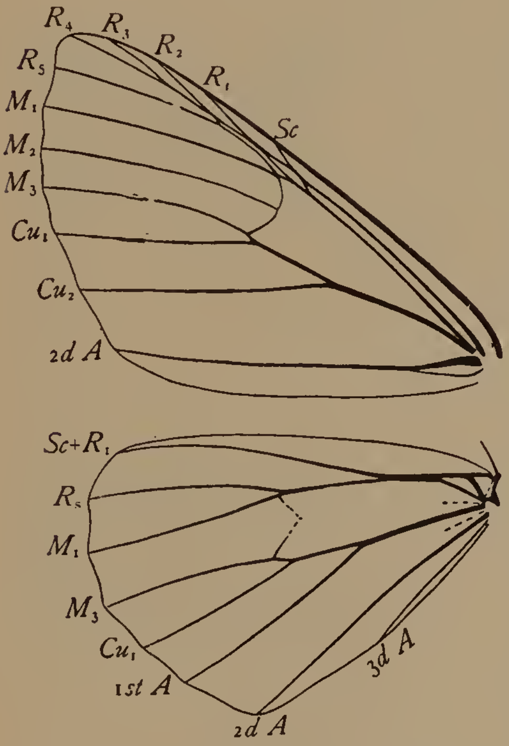


Fig. 385. — Wings of *Caripeta angustiorata.*

The pupæ are slender, and some species are green or mottled in this state. The pupa state is passed in a very flimsy cocoon or in a cell in the ground.

The moths are of medium size, sometimes small, but only rarely very large. Usually the body is slender, and the wings broad and delicate in appearance. These moths occur on the borders of woods and in forests, rarely in meadows and pastures. Their flight is neither strong nor long sustained. Many species when at rest hold the wings horizontally and scarcely overlapping; but other species assume other positions, some similar to butterflies. The type of venation is shown in Figure 385.

There are many species of geometers but the following are best known.

The fall canker-worm, *Alsŏphila pometāria.* — The canker-worms are well-known pests, which are often very destructive to the foliage of fruit-trees and shade-trees. Although they attack many kinds of trees, the apple and the elm are their favorite food-plants.

There are two species of canker-worms which resemble each other to such an extent that they were long confounded; but they differ structurally, and they differ also in habits. The two species agree in being loopers or measuring-worms in the larval state, in the possession of ample wings by the adult male, and in the adult female being wingless. They are easily distinguished however, in all stages, the eggs, larvæ, and adults differing markedly.

The fall canker-worm is so called because the greater number of the moths mature in the autumn and emerge from the ground at this season; but a considerable number come out of the ground in the winter during warm weather, and in the spring. As the females are wingless they are forced to climb up the trunks of trees in order to lay their eggs in a place from which the larvæ can easily find their food. The eggs appear as if cut off at the top, and have a central puncture and a brown circle near the border of the disk. They are laid side by side in regular rows and compact batches, and are generally exposed. They hatch in the spring at the time the leaves appear; and the larvæ mature in about three weeks. In this species there is a pair of vestigial prolegs on the fifth abdominal segment. The pupa state is passed beneath the ground in a perfect cocoon of fine densely spun silk. The adult male is represented by Figure 386. There is a distinct whitish spot near the apex of the fore wings. The moths of both sexes lack the abdominal spines characteristic of the spring canker-worm.

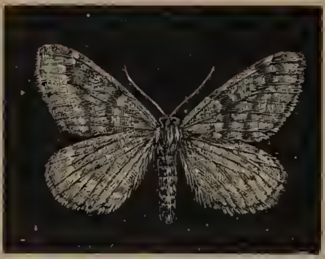


FIG. 386. — *Alsophila pometaria.*

The spring canker-worm, *Paleăcrita vernāta.* — The eggs are ovoid in shape, and are secreted in irregular masses, usually under loose scales of bark or between the leaflets of the expanding buds. The larvæ hatch about the time the leaves expand, and become full-grown in from three to four weeks. They vary greatly in color, and are marked on the back with eight narrow, pale, longitudinal lines which are barely discernible; the two lateral lines of each side are much farther apart than the others; and there are no prolegs on the fifth abdominal segment as in the fall canker-worm. The pupa state is passed below the surface of the ground in a simple earthen cell, which is lined with very few silken threads. The adult moths usually emerge early in the spring before the leaves expand; but they sometimes appear late in the fall, or on warm days during the winter when the ground is thawed. In both sexes the adult of this species is distinguished by the presence of two transverse rows of stiff reddish spines, pointing backwards, on each of the first seven abdominal segments.

The raspberry geometer, *Synchlōra ærāta.* — The larva of this species feeds on the fruit and foliage of raspberry, but chiefly on the fruit. It, like some other members of this subfamily, has the curious habit of covering its body by attaching to it bits of vegetable matter, so that it is masked beneath a tiny heap of rubbish. The wings of the adult are of a delicate pale green color crossed by two lines of a lighter shade; the face is green; and the abdomen is not marked with pink and white ocellate spots, as is the case in certain allied species.

The bad-wing, *Dy̆spteris abortivāria.* — It is easy to recognize this moth (Fig. 387) by the peculiar shape of its wings, the hind wings being greatly reduced in size. It is of a beautiful pea-green color, with two white bands on the fore wings and one on the hind wings. The larva feeds on the leaves of grape, which it rolls.

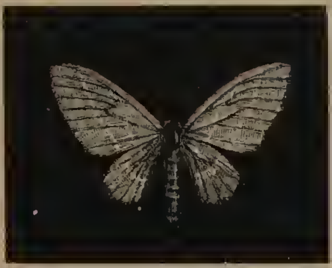


FIG. 387. — *Dyspteris abortivaria.*

The scallop-shell moth, *Calocălpe undulāta.* — This is a pretty moth, with its yellow wings crossed by so many fine, zigzag, dark brown lines that it is hard to tell which of the two is the ground-color (Fig. 388). It lays its eggs in a cluster on a leaf near the tip of a twig of cherry, usually wild cherry. The larvæ make a snug nest by fastening together the leaves at the end of the twig; and within this nest (Fig. 389) they live, adding new leaves to the outside as more food is needed. The leaves die and become brown, and thus render the nest conspicuous. There are two generations in the year. The larvæ of the fall brood are black above, with four white or green stripes, and flesh-colored below; the larvæ of the summer brood are black only on the sides. When full-grown they descend to the ground to transform, and pass the winter in the pupa state.

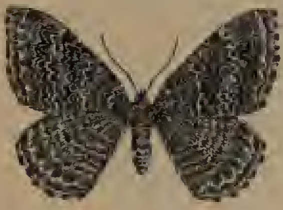


FIG. 388. — *Calocalpe undulata.*

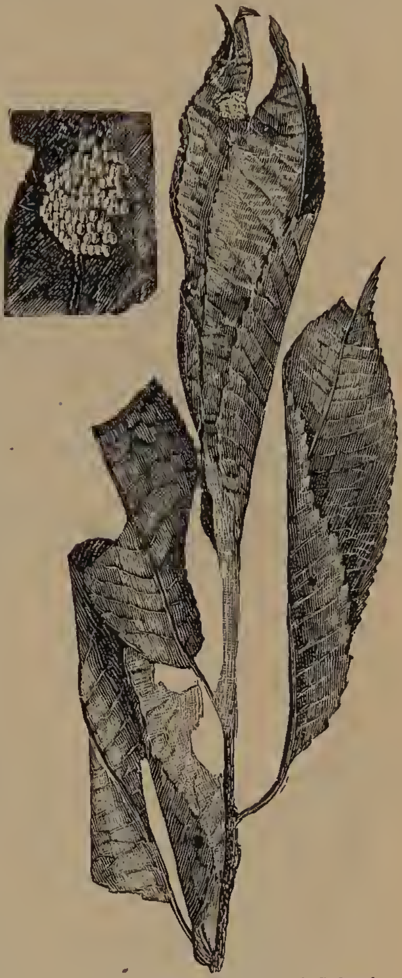


FIG. 389. — Eggs and nest of *Calocalpe undulata.*

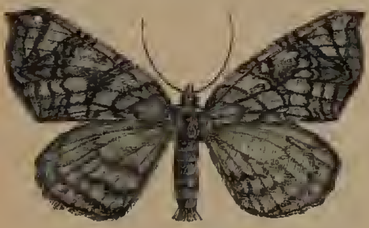


FIG. 390. — *Lygris gracilineata.*

The many-lined moth, *Ly̆gris gracilineāta.* — This moth has pale ochre-yellow wings, with a brownish shade near the outer margin, and crossed by many diverging brown lines (Fig. 390). It varies from 1½ inches to 2 inches in expanse. We have often found this moth on the side of our room, resting on the wall, head downward, and with its abdomen hanging down over its head in a curious manner. The larva feeds on the leaves of grape.

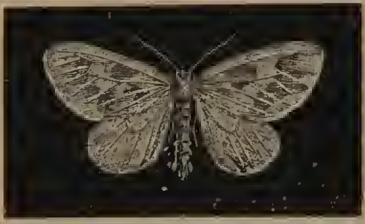


FIG. 391. — *Eudule mendica.*

The beggar, *Eŭdule mendīca.* — One of the most delicate winged moths that we have in the northern Atlantic States is this species (Fig. 391). Although the wings are yellowish-white in color they are almost transparent.

On the fore wings there are two transverse rows of pale gray spots, and a single spot near the outer margin between veins M_3 and Cu_1. (This spot was indistinct in the specimen figured.) The moth is common in midsummer. The larva feeds on violet.

The chain-dotted geometer, *Cingĭlia catenāria.* — This moth has snow-white wings marked with zigzag lines and with dots of black as shown in Figure 392. The head is ochreous-yellow in front; and the thorax is yellowish at the base of the patagia. The moth flies during September and October. The larva feeds on various shrubs and trees. The pupa state is passed in a slight but well-formed web of yellow threads, which is made between twigs or leaves, and through which the pupa can be seen.

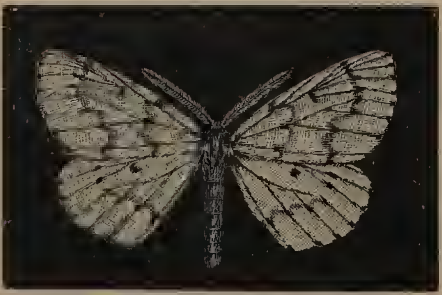


FIG. 392. — *Cingilia catenaria.*

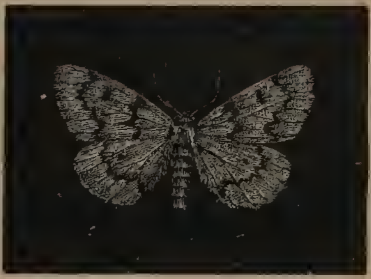


FIG. 393. — *Nepytia semiclusaria.*

The evergreen nepytia, *Nepy̆tia semiclusāria.* — This beautiful moth (Fig. 393) is common in the vicinity of pines, spruce, fir, and hemlock during August and September. It varies from a smoky-ash color to almost snow-white; the wings are marked with black. The larva feeds on the leaves of conifers. It is reddish-yellow above, with lateral yellow bands below, while on each side are two pairs of black hair-lines. There are black spots above on the segments. When full-grown it is a little more than 1 inch long and spins a loose cocoon among the leaves. The chrysalid is green with white stripes and is very pretty.

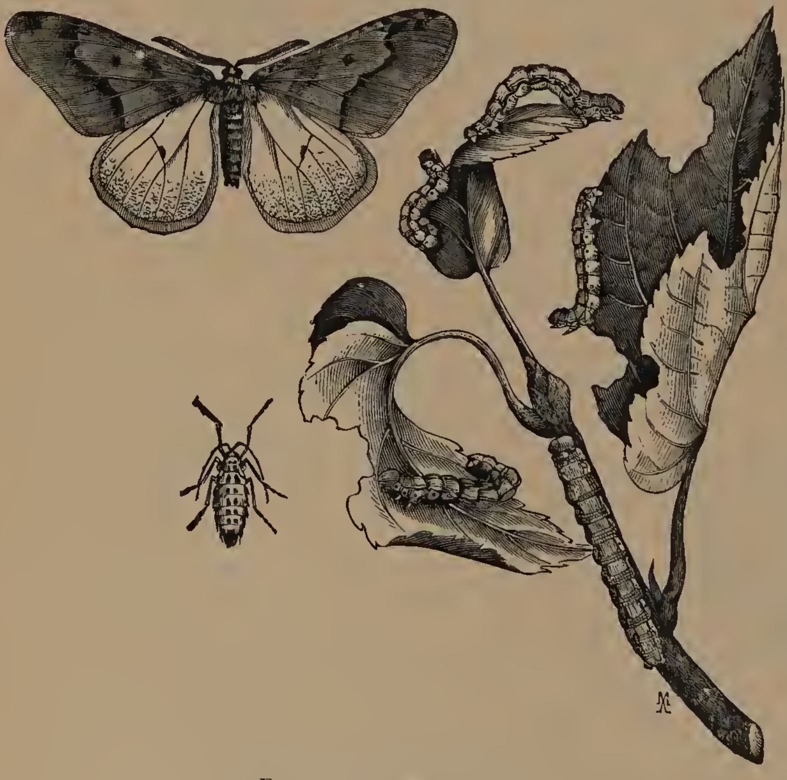


FIG. 394. — *Erannis tiliaria.*

The lime-tree winter-moth, *Erănnis tiliāria.* — This species (Fig. 394) resembles the canker-worms in many particulars. The larva is a looper which infests both fruit and forest-trees; and in the adult state the male has well-developed wings, while the female is wingless.

The eggs are oval, of a pale yellow color, and covered with a network of raised lines. They are thrust by the female under loose bark and in crevices on the trunk and large limbs. They hatch in May, and the larvæ attain their full growth in the latter part of June. The larva is yellow, marked with ten crinkled black lines along the top of the back; the head is rust-colored, and the venter yellowish-white. There is a second form of the larva which is brown above with slate color towards the sides. When full-grown the larva measures about $1\frac{1}{5}$ inches in length. The pupa state is passed in the ground. The moths issue in October or November; and then the wingless females ascend the trees to oviposit as do the females of the canker-worms. The female is represented in the lower left-hand part of the figure. She is grayish in color, with two black spots on the back of each segment except the last, which has only one. The male has pale yellow and brown or buff fore wings, with a central spot and a band beyond the middle, while the hind wings are much lighter.

The notched-wing geometer, *Ĕnnomos magnārius.* — This is one of the larger of our geometrids. The larva is a common looper upon maple, chestnut, and birch trees, and measures about $2\frac{1}{3}$ inches in length when full-grown. It spins a rather dense, spindle-shaped cocoon within a cluster of leaves. The moth (Fig. 395) is ochre-yellow with reddish tinge. The wings are shaded towards the outer margin with brown, and are thickly spotted with small brown dots. The polished greenish-brown to bronze colored eggs are laid side by side in a long linear row on the branches of apple, pear, lilac, and chestnut.

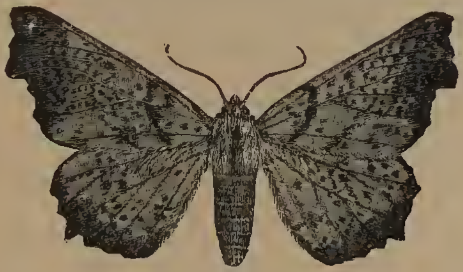


FIG. 395. — *Ennomos magnarius.*

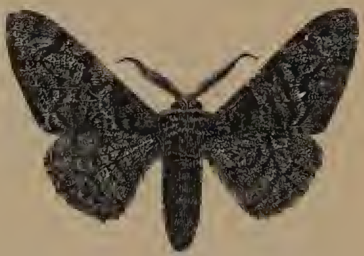


FIG. 396. — *Amphidasis cognataria.*

The pepper-and-salt currant-moth, *Amphĭdasis cognatāria.* — This moth (Fig. 396) differs remarkably in appearance from most geometrids, the body being stouter, and the wings appearing heavier. It can be easily recognized by its evenly distributed pepper-and-salt markings. The larva feeds on various plants, but is found most often on currant.

Family NOTODONTIDÆ

The Prominents

This family includes moths of moderate size, only a few of the larger ones expanding more than 2 inches. The body is rather stout and densely clothed with hair, and the legs, especially the femora, are clothed with long hairs. The wings are strong, and not very broad, the anal angle of the hind wings rarely reaching the end of the abdomen. In their general appearance many of these moths bear a strong resemblance to noctuids. The venation of the wings is illustrated in Figure 397.

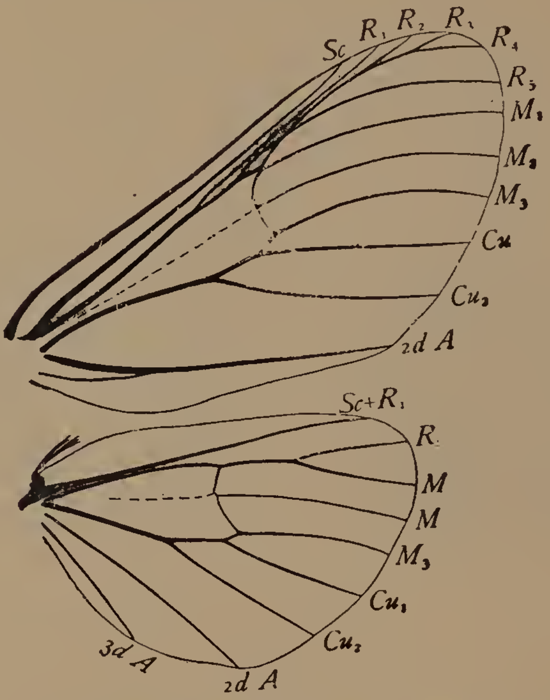


Fig. 397. — Wings of *Hyperæschra stragula.*

In some species the front wings have a prominence or backward projecting lobe on the inner margin, which suggested the common name of *prominents* for these insects (Fig. 398). The name is more generally appropriate, however, for the larvæ, as a much larger proportion of them than of the adults bear striking prominences.

The larvæ feed upon the leaves of shrubs and trees. Our most common species live exposed; but some species live in folded leaves. They are either naked or clothed with hairs. Many species have only four well-developed pairs of prolegs, the anal pair being rudimentary, or transformed into elongated spikes. Some species are hump-backed; and spines or fleshy tubercles are often present. The transformations occur in cocoons or in the ground.

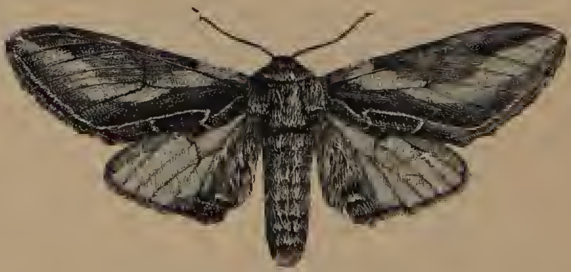


Fig. 398. — *Pheosia rimosa.*

The family Notodontidæ is represented in this country by about one hundred species.

The handmaid moths, *Datana.* — Among the more common representatives of the Notodontidæ are certain brown moths that have the fore wings crossed with bars of a different shade (Fig. 399) and that bear on the fore part of the thorax a conspicuous patch of darker color. In most of our species the fore wings are also marked with a dot near the center of the discal cell and a bar on the discal vein. These moths belong to the genus *Datāna.* The common name, handmaid, is a translation of the specific name of our most common species, *D. minĭstra.* But as this species is now generally known as the yellow-necked apple-tree worm, and as all of our species are dressed in sober attire as becomes modest servants, we have applied the term handmaid moths to the entire genus.

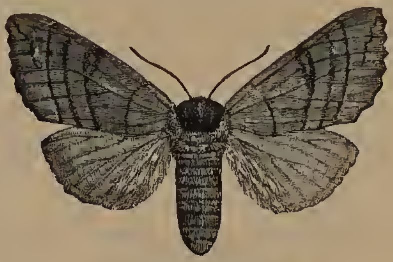


Fig. 399. — *Datana ministra.*

The larvæ of the handmaid moths are easily recognized by their peculiar habits. They are common on various fruit and forest-trees, but especially on apple, oak, and hickory.

They feed in colonies; and have the habit of assuming the curious attitude shown in Figure 400. The body is black or reddish, marked with lines or stripes of yellow or white. Owing to the gregarious habits of these larvæ they can be easily collected from the trees they infest.

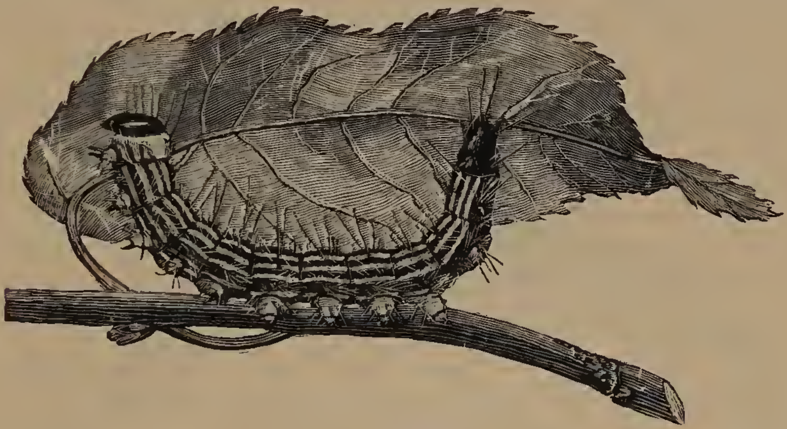


Fig. 400. — *Datana,* larva.

All the species that we have studied agree in being single-brooded, the moths appearing in midsummer; the eggs are laid in a cluster on a leaf; the larvæ are conspicuous in August and September. In some of the species the larvæ have the curious habit of leaving the branch upon which they are feeding when the time to molt arrives, the whole colony gathering in a large mass on the trunk of the tree, where the molt takes place. The pupa state is passed in the ground, in a very light cocoon or in none at all, and lasts about nine months in the species that we have bred.

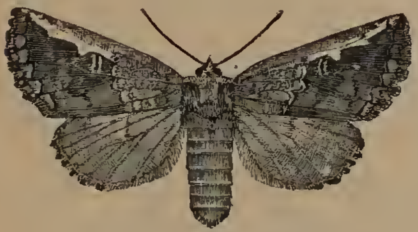


Fig. 401. — *Symmerista albifrons.*

The white-tipped moth, *Symmerĭsta ălbifrons.* — This beautiful moth, which is quite common, can be easily recognized by the accompanying figure (Fig. 401); the white patch, which extends along the costa of the fore wing for half the length from the tip, being very characteristic. The larva is quite common in the autumn on leaves of oak. It is known as the red-humped oak-caterpillar; it is smooth and shining, with no hairs; along each side of the back there is a yellow stripe, and between these, on the back, fine black lines on a pale lilac ground; on each side below the yellow stripes there are three black lines, the lowest one just above the spiracles. The head is orange-red; and there is an orange-red hump on the eighth abdominal segment.

Fig. 402. — *Heterocampa bilineata*, larva.

The two-lined prominent, *Heterocămpa bilineāta.* — The larva of this species (Fig. 402) is much more apt to be observed than the adult. It is common in the latter part of the summer and in early autumn, feeding on the leaves of elm, beech, and basswood. It measures when full-grown about $1\frac{1}{2}$ inches in length. Its ground-color is usually green, but sometimes claret-red. There is a pale yellow stripe along the middle of the back, and on each side a stripe of the same color. The course of these side stripes is very characteristic; passing back from the head, they converge on the prothorax; on the mesothorax and metathorax they are separated from the dorsal line only by a narrow band of red or purple; on the first abdominal segment they diverge to the lateral margin of the back, but converge again on the seventh and eighth abdominal segments. This yellow subdorsal line is bordered without by a milk-white stripe; and extending from this stripe over the side of the body there is a whitish shade which fades out below. The moth is ash-colored, with the fore-wings crossed by two wavy lines between which the wing is darker; between the outer wavy line and the outer margin of the wing there is a faint band.

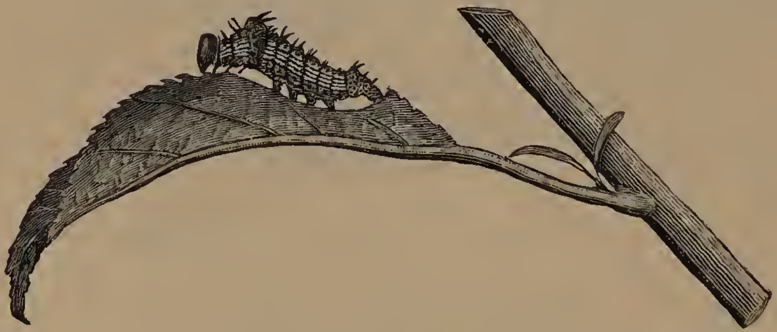


Fig. 403. — *Schizura concinna*, larva.

The red-humped apple-worm, *Schizūra concĭnna.* — The larva of this species (Fig. 403) is common on apple and allied plants. The head is coral-red, and there is a hump of the same color on the back of the first abdominal segment; the body is striped with slender black, yellow, and white lines, and has two rows of black spines along the back, and other shorter ones upon the sides. When not eating, the larvæ remain close together, sometimes completely covering the branch upon which they rest. This species passes the winter in the pupa state. The adults appear in June and July.

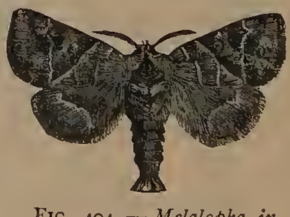


Fig. 404. — *Melalopha inclusa.*

The poplar mocha-stone moth, *Melălopha inclūsa.* — The adult (Fig. 404) is a brownish-gray moth with the fore wings crossed by three irregular whitish lines. The basal line is broken near the middle of the wing; and the intermediate one forms an inverted Y, the main stem of which joins the third line near the inner margin of the wing, making with it a prominent V. These lines are bordered without by rust-red; there is a chocolate-colored spot near the apex of the fore wings, and an irregular row of blackish dots near the outer margin. The hairs of the thorax form a prominent crest, the fore side of which is a rich dark brown. The hind wings are crossed by a wavy band, which is light without and dark within.

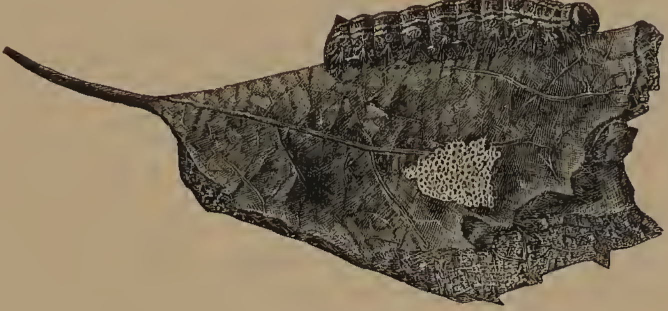


Fig. 405. — Eggs, larva, and nest of *Melalopha inclusa*.

The eggs are nearly spherical and smooth; they are deposited in a cluster a single layer deep on a leaf (Fig. 405). When the larvæ hatch they make a nest either by fastening several leaves together or, as is the case when they infest poplar, by folding the two halves of a single leaf together; frequently in the latter case the tip of the leaf is folded in as shown in the figure. Within this nest the entire colony lives, feeding on the parenchyma, and causing the leaf to turn brown. Later other leaves are added to this nest or additional nests are made among adjoining leaves. All of these infested leaves are securely fastened to the twig by bands of silk. When the larvæ become large they leave their nests at night to feed upon other leaves. These they entirely consume excepting the petioles, midribs, and larger veins.

The full-grown larva measures 1$\frac{2}{5}$ inches in length. It is striped with pale yellow and brownish-black, and bears a pair of black tubercles close together on the first abdominal segment, and a similar pair on the eighth abdominal segment. The cocoon is an irregular thin web; it is made under leaves or other rubbish on the ground. The insect remains in the pupa state during the winter, and emerges as a moth in the latter part of June or later. In the South this species infests willow as well as poplar, and is double-brooded.

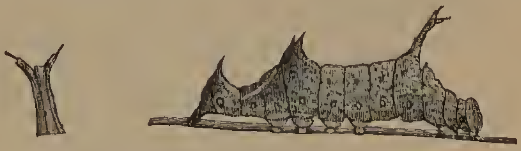


Fig. 406. — *Schizura ipomeæ*, larva; tubercle enlarged at left.

Among the more grotesque larvæ belonging to this family are those of the genus *Schizura*, of which we have several species. Figure 406 represents the larva of *Schizura ipomeæ*. At the left in the figure is shown a front view of the longest tubercule. This species feeds on oak, maple, and many other plants. In the Gulf States it feeds on *Ipomea coccinea*, which fact suggested its specific name.

Family Lymantriidæ

The family Liparidæ of some writers

The Tussock-moths

The larvæ of these moths are among the most beautiful of our caterpillars, being clothed with brightly-colored tufts of hairs; and it is to this characteristic clothing of the larvæ that the popular name *tussock-moths* refers.

The adult moths are much plainer in appearance than the larvæ; and in the genera, to which our most common species belong, the females are practically wingless, the wings being at most short pads, of no use as organs of flight.

The tussock-moths are of medium size, with the antennæ of both sexes when winged pectinated, those of the males very broadly so; the wingless females have serrate or narrowly pectinate antennæ.

The larvæ of our native species are very characteristic in appearance. The body is hairy; there are several conspicuous tufts of hairs on the dorsal aspect of the abdomen, and at each end of the body there are long pencils of hairs; on the sixth and seventh abdominal segments there is on the middle of the back of each an eversible gland supposed to be a scent-organ similar to the osmateria in the larvæ of *Papilio*, and it is stated that a fine spray of liquid is sometimes thrown from them.

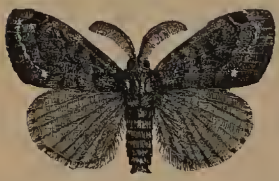


Fig. 407. — *Hemerocampa leucostigma.*

The white-marked tussock-moth, *Hemerocămpa leucostĭgma.* — This is our most common representative of the family. It frequently occurs in such great numbers that it seriously injures the foliage of shade-trees and orchards. The male (Fig. 407) is of an ashy-gray color; the fore wings are crossed by undulated bands of darker shade and bear a conspicuous white spot near the anal angle. The female is white and resembles a hairy grub more than a moth. She emerges from her cocoon and after pairing lays her eggs upon it, covering them with a frothy mass. The larva (Fig. 408) is one of the most beautiful of our caterpillars. The head and the glands on the sixth and seventh abdominal segments are bright vermilion-red. There is a velvety black dorsal band, bordered with yellow subdorsal stripes; and there is another yellow band on each side just below the spiracles. The prothorax bears on each side a pencil of

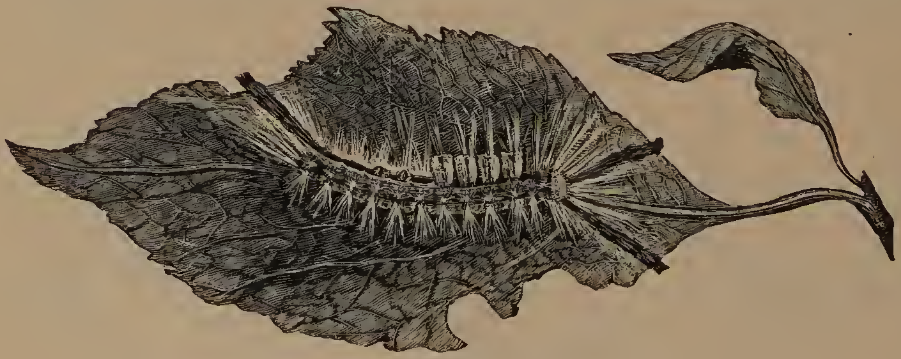


Fig. 408. — *Hemerocampa leucostigma*, larva.

long black hairs with plume-like tips; a similar brush is borne on the back of the eighth abdominal segment, and the first four abdominal segments bear dense brush-like tufts of cream-colored or white hairs.

The California tussock-moth, *Hemerocămpa vetūsta.* — The white-marked tussock-moth described above is found only in the East; this species is found in California, where it is common on live oak and yellow lupin trees, and has injuriously infested apple and cherry orchards. The larvæ have black heads, crimson hair-bearing warts and prolegs, and the four tussocks or brush-like tufts of hairs on the back are often dark gray with brownish crests. In general the life-history of this species is similar to that of the eastern species.

The old tussock-moth, *Notŏlophus antīqua.* — The male is of a rust-brown color; the fore wings are crossed by two deeper brown bands and have a conspicuous white spot near the anal angle. The body of the grub-like female is black, clothed with yellowish-white hairs; she lays her eggs on her cocoon, but, unlike the two preceding species, does not cover them with anything. The larva differs from either of the preceding in having an extra pair of pencils of plume-like hairs arising from the sides of the second abdominal segment; the head is jet-black; the glands on the sixth and seventh abdominal segments are vermilion-red or sometimes bright orange; and the tubercles on the sides of the back of the second and third thoracic and the sixth and seventh abdominal segments are orange-red or yellow margined with pale yellow.

The gypsy moth, *Porthētria dĭspar.* — This is a European species which was introduced in Massachusetts in 1866 by a French naturalist who was conducting experiments with silk-worms. Some of the insects escaped from him into a neighboring woodland and became established there; but they did not attract particular attention till about twenty years later. It was then realized that this species is a serious pest. Since then millions of dollars have been expended by the State of Massachusetts and the Federal Government in an unsuccessful effort to exterminate it. It has spread over a large part of New England, and isolated colonies have been found in New York. The larva has a wide range of food-plants, feeding on the foliage of most forest and fruit-trees. The male moth is brown; the female white (Fig. 409). In each the fore wings are crossed by many dark lines and bear a black lunule on the discal vein. The specimen figured is unusually small. The eggs are laid in a mass on any convenient object and are covered with hair from the abdomen of the female. The larva differs greatly in appearance from those of the preceding genera, lacking the peculiar pencils and tufts of hair; but the characteristic glands of the sixth and seventh abdominal segments are present and are red. The body is dark brown or black, finely reticulated with pale yellow, and with narrow yellow dorsal and subdorsal lines. On the dorsal aspect of each segment there is a pair of prominent, rounded tubercles bearing spiny black hairs. The first five pairs of these tubercles are bluish, the others dark crimson-red. There are also two rows of tubercles on each side of the body which bear longer hairs.

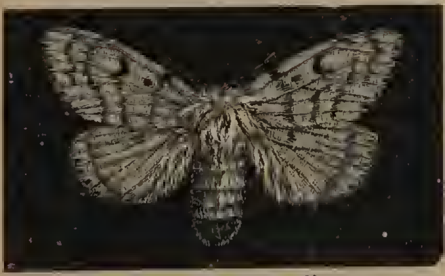


Fig. 409. — *Porthetria dispar.*

The brown-tail moth, *Euprŏctis chrysorrhœa.* — The brown-tail moth is another European pest, which was introduced into Massachusetts. It first attracted attention by its ravages in 1897, and since then has spread over a considerable part of New England and has extended into New Brunswick and Nova Scotia. The wings of the female moth are white; and the tip of the abdomen bears a tuft of yellowish-brown hairs, hence the popular name of the insect. The female expands about 1½ inches. The male is a little smaller than the female; and the brownish tuft at the end of the abdomen is not so conspicuous as in the female. The larva feeds on the foliage of fruit-trees and of almost all kinds of shade-trees except conifers. The eggs are laid in an elongate mass on the underside of a leaf, during July. The egg-mass is covered with brownish hairs from the tip of the abdomen of the female. The eggs hatch in two or three weeks. The larvæ hatching from an egg-mass feed together on adjoining leaves at the tip of a branch. These they web together with silk, making a nest within which they pass the winter in a partially grown condition. In early spring the larvæ leave their winter quarters and feed on the expanding foliage. They become full-grown in five or six weeks; and then spin thin cocoons of white silk in curled leaves, crevices in bark of trees, or under any convenient shelter. About three weeks later the moths emerge.

The full-grown larva of the brown-tail moth measures about 1½ inches in length. It is nearly black in ground color, clothed with tufts of brownish barbed hairs, and has a row of nearly white tufts on each side of the body. In the center of the sixth and seventh abdominal segments are small, red, retractile tubercles. The barbed hairs borne by the subdorsal and lateral tubercles are venomous and produce an inflammation of the skin of man much like that caused by poison ivy. As the cast skins of the larvæ are blown about by the wind, people are frequently badly poisoned where this pest is common.

Family Noctuidæ

The Noctuids or the Owlet-moths

If only our fauna be considered, this is the largest of all of the families of the Lepidoptera; more than 2500 species of noctuids are now know to exist in America north of Mexico. The great majority of the moths that fly into our houses at night, attracted by lights, are members of this family. The nocturnal habits of these insects, and the fact that often when they are in obscurity their eyes shine brightly suggested the name of the typical genus, *Noctua*, from the Latin for owl, as well as the popular name owlet-moths, by which they are known. Similar popular names have been given them in several other languages.

Although there exist within the limits of the family great differences in size, form, and coloring, most of the species are dull-colored moths of medium size.

In the typical noctuids, the body is large in proportion to the size of the wings; the front wings are strong, somewhat narrow, and elongated, the outer margin being shorter than the inner margin; and when at rest, the wings are folded upon the abdomen, giving the insect a triangular outline. The antennæ are thread-like, fringed with hairs, or brush-like, or frequently pectinate in the males. Two ocelli are almost always present. The labial palpi are well developed, and in some species quite prominent. The maxillæ are quite long and stout in most species. The thorax is heavy and stout. In the majority of the species the scales on the dorsal surface of the thorax are turned up more or less, forming tufts. The abdomen is conical and extends beyond the anal angle of the hind wings when these are spread. Figure 410 shows the type of venation.

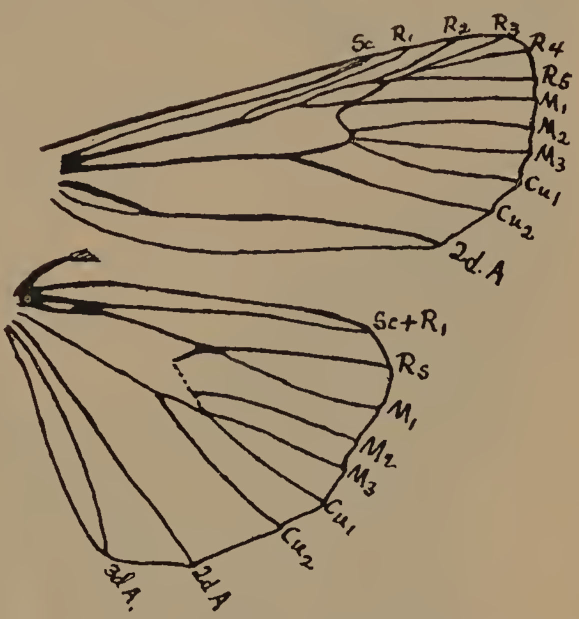


FIG. 410. — Wings of a noctuid, *Agrotis ypsilon.*

The majority of the larvæ are naked, of dull colors, and provided with five pairs of prolegs. As a rule they feed on the leaves of plants, but some are borers and some gnaw into fruits. Among them are some of the more important insects injurious to agriculture.

The family Noctuidæ has been divided into many subfamilies. In the following pages the more important of those represented in our fauna are briefly discussed, in order to show, as well as possible in a limited space, the variations in form included in this family, and to indicate the position of our more important species.

THE DELTOIDS

There is a group of moths, the deltoids, which are placed at the foot of this family on account of their apparent relationship to the geometrids and to the pyralids. These moths are usually of dull colors and of medium size. The name deltoids was suggested by the triangular outline of the wings when at rest, which is well represented by the Greek letter delta. When in this position the wings slope much less than with other noctuids, the attitude being more like that assumed by the geometrids. Two species of this group will serve as examples.

The green clover-worm, *Plathypēna scābra.* — This is a common deltoid. The usual food-plant of the larva is clover, but it occasionally defoliates peas, beans and lima beans. It is a slender green worm measuring when full-grown $\frac{3}{5}$ of an inch in length and only about $\frac{1}{10}$ of an inch in width in its widest part; it has a narrow subdorsal whitish line and a lateral one of the same color. When ready to transform it webs together several leaves and passes the pupa state in the nest thus made. The adult (Fig. 411) is a blackish-brown moth, with an irregular grayish shade on the outer half of the fore wings, and with very broad hind wings. The palpi, which are not well shown in the figure, are long, wide, and flattened; they project horizontally like a snout.

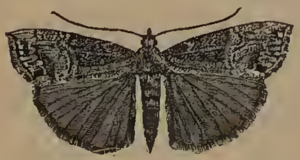


FIG. 411. — *Plathypena scabra.*

The hop-vine deltoid, *Hypēna hūmuli.* — This species is closely allied to the preceding and has often been confounded with it. The larva feeds on the leaves of hop, and is sometimes a serious pest.

THE DARK NOCTUIDS

There is a large group of noctuid moths many of which are decidedly dark in color and of which the black witch is the most striking example. The three following species are of this group.

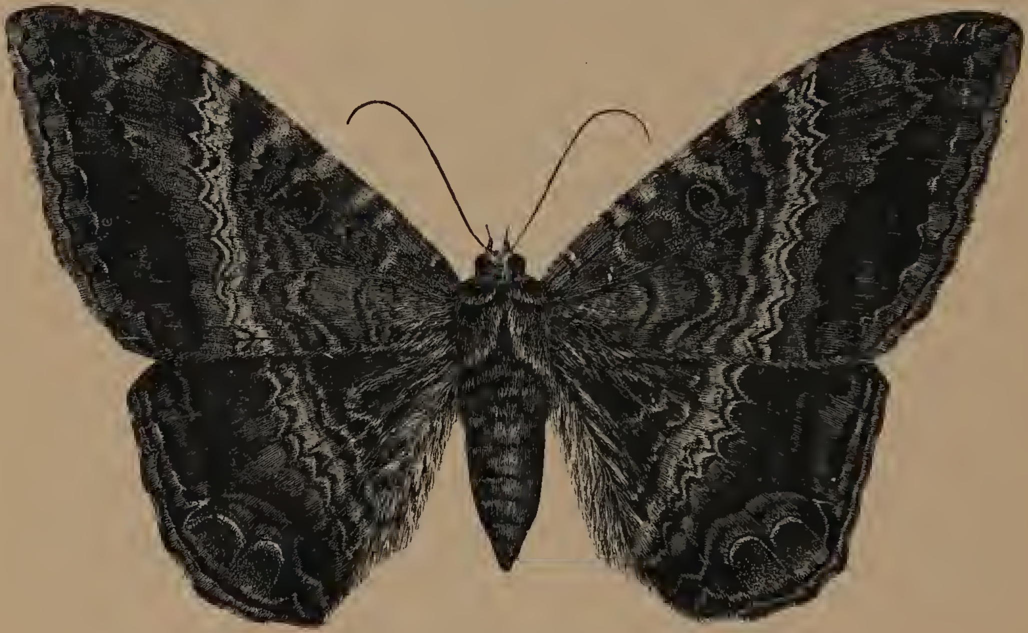


FIG. 412. — *Erebus odora.*

The black witch, *Erebus odōra.* — This is the most magnificent in size of all of the noctuids found in this country (Fig. 412). There is much variation in the depth of coloring. The individual figured is a female; in the male the fore wings are more pointed at the apex and the medium band is indistinct. It is a native of the West Indies; but it is believed that it breeds in the extreme southern portion of the United States. Isolated individuals are found in the North in late summer or autumn. These are found as far north as Canada and west to Colorado, and even in California. These have doubtless flown north from their southern breeding places, possibly from Cuba or Mexico. The larva feeds on certain tropical leguminous trees.

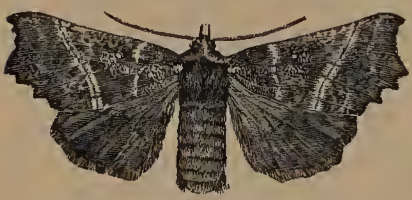


FIG. 413. — *Scoliopteryx libatrix.*

The scalloped owlet, *Scoliŏpteryx libātrix.* — This moth is easily recognized by the shape of its wings, the outer margins of which are deeply cut and scalloped (Fig. 413). The color of the fore wings is soft brownish-gray, slightly powdered with rust-red, and frosted with white along the costa. There is an irregular patch of rust-red reaching from the base to the middle of the wing, a single, white, transverse line before the middle, and a double one beyond the middle. The larva feeds on willow. This species is found in all parts of the United States and in Europe.

The cotton-worm *Alabāma argillăcea.* — This is an important insect pest in the cotton-growing states. The adult insect (Fig. 414) is a brownish moth with its fore wings crossed with wavy lines of darker color and marked with a bluish discal spot and two white dots as shown in the figure. This moth is found in the northern states and even in Canada in the latter part of the summer and in the autumn. But this occurrence in the North is due to migrations from the South, as the insect can not survive the winter north of the tropics. The larva feeds on the foliage of cotton; and as there are five or six generations in a year, the multiplication of individuals is very rapid, and the injury to the cotton great.

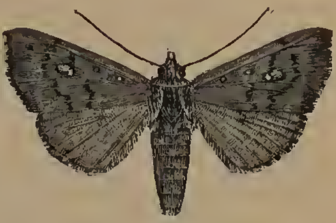


Fig. 414. — *Alabama argillacea.*

The Plusias

There are nearly seventy species of moths in this group of which most of the typical members were formerly placed in the genus *Plusia.*

In a large number of these the fore wings are marked with metallic-colored scales. The most common form of this marking is a silvery spot, shaped something like a comma, near the center of the wing (Fig. 415). In some of the species the metallic markings cover a large portion of the fore wings, in others they are wanting.

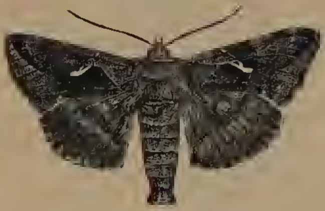


Fig. 415. — *Autographa falcifera.*

The larvæ have only three pairs of prolegs, the first two pairs being wanting; due to this fact they walk with a looping motion (Fig. 416) resembling somewhat that of the geometrids.

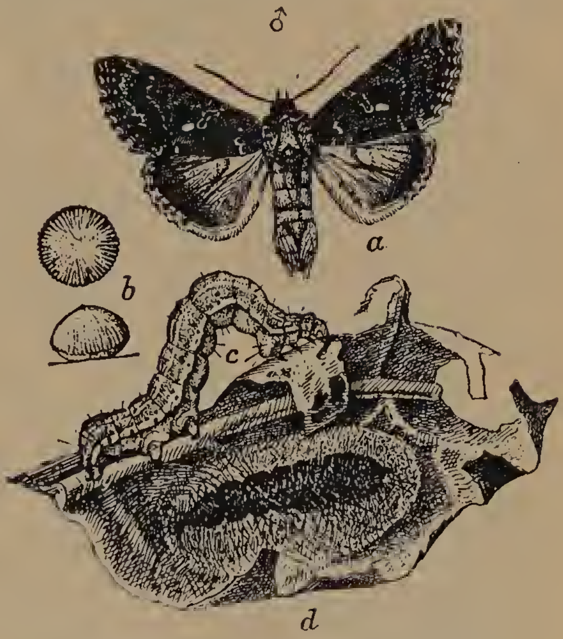


Fig. 416. — The cabbage-looper, *Autographa brassicæ: a,* male moth; *b,* egg; *c,* full-grown larva; *d,* pupa in cocoon. (After Howard and Chittenden.)

The two following species have attracted attention by their injuries to cultivated plants; the celery looper, *Autŏgrapha falcĭfera,* and the cabbage looper, *Autŏgrapha brăssicæ.*

The Catocalas

There are many species in North America of these handsome moths but as a rule their caterpillars are not of much economic importance.

The most striking in appearance of the noctuids, if we except the black witch and one or two allied species, are the moths belonging to the genus *Catocala*. These moths are of large size, often expanding 3 inches or more. The fore wings are usually brown or gray, marked with wavy or zigzag lines. The ground-color of the hind wings is black; but in many species these wings are conspicuously banded with red, yellow, or white. This peculiarity has suggested the name underwings by which these insects are commonly known in England. The genus is a very large one; more than 100 species are now known from this country; and many of these are extremely variable, so that nearly twice that number of named forms are now recognized. The ilia underwing, *Catŏcala ĭlia*, will serve as an example (Fig. 417). The larvæ of the underwings feed on the leaves of various forest trees. Many species infest oak and hickory. By careful search both the adults and larvæ can be found resting on the trunks of these trees; but it needs sharp eyes to do it, as the colors of these insects are usually protective, the bright-colored hind wings of the moths being covered by the fore wings when the insect is at rest.

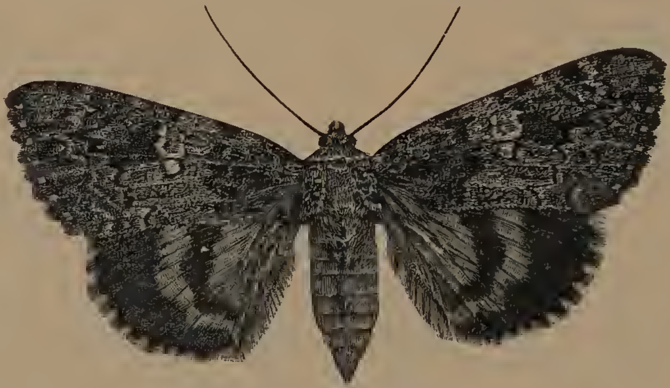


FIG. 417. — *Catocala ilia.*

In the same group with the underwings are the *clover-looping owlets.* — Among the more common noctuids that occur in our meadows and pastures, and that fly up before us as we walk through them, are two species belonging to the genus *Cænurgia*. These may be called the clover-looping owlets; for the larvæ feed on clover, and, as they have only three pairs of prolegs they walk in a looping manner. One of these species is *Cænŭrgia erĕchtea*. This moth (Fig. 418) has dark or light drab-gray fore wings, which are marked by two large dark bands, as shown in the figure. These bands are always separate, distinct, and well defined towards the inner margin in the male; in the female the markings are much less distinct, the bands usually invisible.

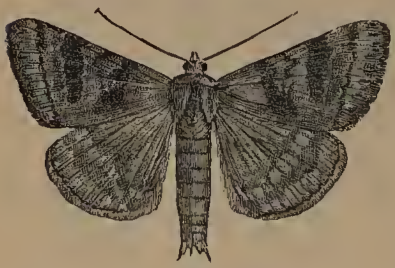


FIG. 418. — *Cænurgia erechtea.*

The other common species of this genus is *Cænŭrgia crassiŭscula*. In this species the fore wings have either a distinct violaceous brown or a red or buffy shade, with the two large dark bands very variable, often shading into the ground-color on the outer edge or coalescing near the inner margin; all the markings are equally distinct in both sexes.

THE DAGGERS

Nearly one hundred species of this group belong to the typical genus *Apatēla*, which is named *Acronycta*, by some authors. There are also many other forms in this group with the daggers.

The fore wings of these moths are generally light gray with dark spots, and in many species have a dagger-like mark near the anal angle. On this account they have received the name of *daggers*. The larvæ exhibit much diversity in appearance; those of some species are hairy like the larvæ of arctiids, while others are nearly naked.

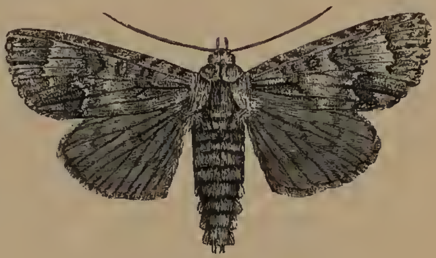


FIG. 419. — *Apatela morula.*

The ochre dagger, *Apatēla mŏrula.* — This moth (Fig. 419) is pale gray with a yellowish tinge. Besides the black line forming part of the dagger near the anal angle of the fore wing, there is a similar black line near the base of the wing, and a third near the outer margin between veins M_1 and M_2. The larva feeds on elm and basswood. When full-grown it is mottled brown and greenish like bark; it is clothed with but few scattered hairs, and has a hump on the first, fourth, and eighth abdominal segments.

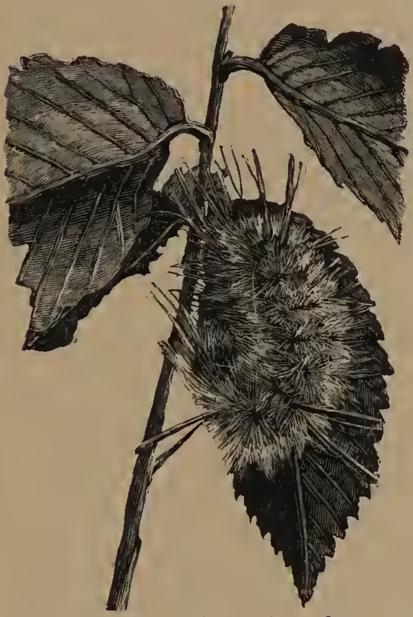


FIG. 420. — *Apatela americana*, larva.

The American dagger, *Apatēla americāna.* — This is a gray moth resembling in its general appearance the preceding, but with the black lines on the fore wings much less distinct. Its larva, however, is very different (Fig. 420). This larva looks like an arctiid, being densely clothed with yellow hairs. But these hairs are scattered over the surface of the body instead of growing from tubercles as with the larvæ of arctiids. Along the sides of the body and at each end are a few scattered hairs that are longer than the general clothing, and there are two pairs of long black pencils borne by first and third abdominal segments, and a single pencil on the eighth abdominal segment. When at rest the larva remains curled sidewise on a leaf, as shown in the figure. It feeds on maple, elm, and other forest trees.

The stalk-borer, *Papaipēma nēbris.* — The larva is a borer in the stalks of potato, tomato, corn, dahlia, aster, and other plants. It is about 1½ inches long and has five white stripes, one along the back and two along each side of the body. The side stripes fade out on the first segment of the abdomen. The moth has olive front wings expanding about 1½ inches with three white spots on the inner third of each and a yellow crescent with three to five dots near the white crossline. The other common form, *nitēla*, has darker olive wings without any white dots and is slightly smaller.

The brown-tailed diver, *Bellura diffūsa.* — One of the most remarkable exceptions to what are usually the habits of members of this order is presented by the larva of this species. This larva is able to descend into water and remain there for a long time.

The young larvæ of this species have not been observed; doubtless they are leaf-miners. The older larvæ live in the leaf-stalks of the pond-lily, a single larva in a leaf-stalk. The larva bores a hole from the upper side of the leaf into the petiole, which it tunnels in some instances to the depth of two feet or more below the surface of the water. This necessitates its remaining below the surface of the water while feeding. The tracheæ of these larvæ are unusually large, and we believe that they serve as reservoirs of air for the use of the insect while under water. The form of the hind end of the larva has also been modified, so as to fit it for the peculiar life of the insect. The last segment appears as if the dorsal half had been cut away; and in the dorsal part of the hind end of the next to the last segment, which, on account of the peculiar shape of the last segment, is free, there open a pair of spiracles much larger than those on the other segments. When not feeding the larva rests at the upper end of its burrow, with the segment bearing these large spiracles projecting from the water.

The Armyworms

Not all of the moths in this group have caterpillars that are gregarious and march over the ground in great numbers. Some are simply cutworms with the habits of ordinary cutworms although most of these pests are found in the next group.

The armyworm, *Cĭrphis unipŭncta.* — The armyworm is so called because it frequently appears in great numbers, and, after destroying the vegetation in the field where the eggs are laid, marches like an army to other fields. It is, however, a simple cutworm in most years. This insect occurs throughout the United States east of the Rocky Mountains and is present every year; but it attracts attention only when it appears in great numbers. The larva is from $1\frac{1}{2}$ to 2 inches long when full-grown and is striped with black, yellow, and green. The adult is of a dull brown color, marked in the center of each fore wing with a distinct white spot (Fig. 421). In seasons of serious outbreak of this pest it usually appears first in limited areas, in meadows or pastures.

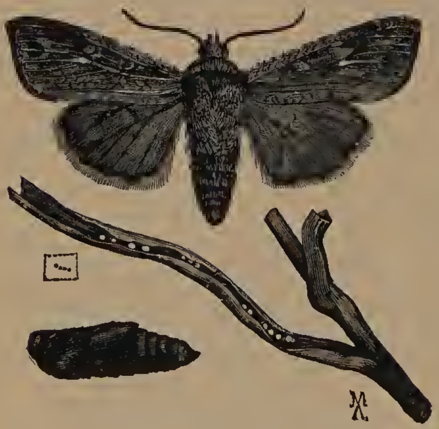


Fig. 421. — *Cirphis unipuncta.*

The green fruit-worms. — There are three species, *Xylīna antennāria, X. laticinēria, and X. grōtei*, the larvæ of which attack the fruit of the apple, pear, peach and plum. The caterpillars are yellowish-green or apple-green in color, about $1\frac{1}{2}$ inches long and much alike in appearance. They eat cavities in the sides of the fruit, which scar and deform the apples and pears especially.

The moths of the three species are gray in color, very similar in appearance and with a wing-expanse of about $1\frac{3}{4}$ inches.

THE CUTWORMS

This last group of the noctuids is a very large one containing more than 500 species. The larger number of our common cutworms belong to this group but there are other members of the group which have very different habits.

Few pests are more annoying than the rascally little cutworms that nightly, in the spring, cut off our corn and other plants before they are fairly started. There are many species of these cutworms, but they are all the larvæ of owlet-moths. In general their habits are as follows: the moths lay their eggs during midsummer. The larvæ soon hatch, and feed upon the roots and tender shoots of herbaceous plants. At this time, as the larvæ are small and their food is abundant, they are rarely observed. On the approach of cold weather they bury themselves in the ground and here pass the winter. In the spring they renew their attacks on vegetation; but now, as they are larger and in cultivated fields the plants are smaller, their ravages quickly attract attention. It would not be so bad if they merely destroyed what they eat; but they have the unfortunate habit of cutting off the young plants at the surface of the ground, and thus destroy much more than they consume. They do their work at night, remaining concealed in the ground during the daytime. When full-grown they form oval chambers in the ground in which they pass the pupa state. The moths appear during the month of June to September.

There are some exceptions to these generalizations: some species of cutworms ascend trees during the night and destroy the young buds; many pass through two generations in the course of a year; and a few pass the winter in the pupa state.

The corn earworm or the cotton-boll worm, *Heliōthis obsolēta.* — This is a widely distributed pest, the larva of which infests many different plants. It is often found feeding on the tips of ears of growing corn, especially of sugar-corn. And it is also one of the more important of the pests of cotton, ranking next to the boll-weevil and the cotton-worm; the larva bores into the pods or bolls of the cotton, destroying them. It frequently infests tomatoes, eating both the ripe and the green fruit. Occasionally it is found within the pods of peas and of beans, eating the immature seeds. It also bores into the buds, seed-pods, and flower-stalks of tobacco. The full-grown larva measures from 1$\frac{1}{5}$ to 1$\frac{3}{5}$ inches in length. It varies greatly in color and markings. The pupa state is passed in the ground. The number of generations annually varies according to latitude; there is probably only one in Canada, but in the Gulf States there are from four to six. Like the larva, the moth is extremely variable in color and markings.

Family AGARISTIDÆ

The Foresters

This family seems to be growing smaller for some of the familiar genera formerly included in it have been removed to the Noctuidæ. There are only sixteen species left in the family and but one of these is commonly known.

The eight-spotted forester, *Alӯpia octomaculāta.* — This species is of a deep velvety-black color. The front wings have two large sulphur-yellow spots; and the hind wings, two white spots. The tegulæ are sulphur-yellow.

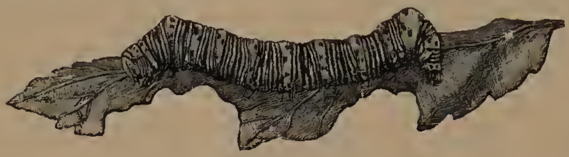


FIG. 422. — *Alypia octomaculata*, larva.

The larva (Fig. 422) feeds upon the leaves of grape and Virginia-creeper, and sometimes occurs in such large numbers as to do serious injury. The ground-color of the larva is white, with eight black stripes on each segment, and a broader orange band, bounded by the two middle stripes; the orange bands are marked by black, conical, elevated spots. There are usually two broods each year, the moths appearing on the wing in May and August, the caterpillars in June and July, and in September. The pupa state is passed in an earthen cell in the ground.

This species is found in the Atlantic States from Massachusetts to Texas.

Family ARCTIIDÆ

The Tiger-moths and Footman-moths or Arctiids

The Arctiidæ includes stout-bodied moths, with moderately broad wings, which in the majority of cases are conspicuously striped or spotted, suggesting the popular name tiger-moths; some of the species, however, are unspotted. A large proportion of the species are exceedingly beautiful; this renders the family a favorite one with collectors. As a rule, when at rest, the wings are folded, roof-like upon the body. Most of the moths fly at night, and are attracted to lights. Those moths of this family which are white with black spots are known in this country as ermine moths.

The larvæ of the tiger-moths, except that of *Utetheisa*, are clothed with dense clusters of hairs. In fact a large proportion of our common hairy caterpillars are members of this family. In some species, certain of the clusters of hairs are much larger than the others, resembling in this respect the clothing of the tussock-moths. Most larvæ of the arctiids feed upon herbaceous plants, and many species seem to have but little choice of food-plant; but certain common species feed upon leaves of forest trees.

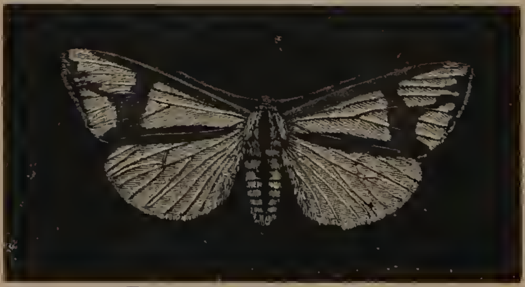


FIG. 423. — *Haploa contigua*.

Hăploa contĭgua. — This species (Fig. 423), is one of a number of very handsome moths belonging to the genus, *Haploa*. Some are snow-white or light yellow with the fore wings banded with brown. They vary greatly in their markings.

The harlequin milkweed caterpillar, *Euchætias ĕgle*. — This larva is the most common caterpillar found on milkweed. It is clothed with tufts of orange, black, and white; those at each end of the body are longer than the others and are arranged radiately (Fig. 424). When full grown the larva makes a felt-like cocoon composed largely of its hairs.

The adult has mouse-gray wings; the abdomen is yellow, with a row of black spots along the middle of the back.

The tiger-moth, *Apantēsis vĭrgo.* — This moth is probably one of the most typical and striking in appearance of all the tiger-moths. The front wings are velvety-black marked with cream-colored bands. The hind wings are reddish with black spots and the stout abdomen is also red with a row of black spots down the middle of the back and a similar row along each side (Fig. 425). There are other members of this genus similarly marked in striking and attractive patterns.

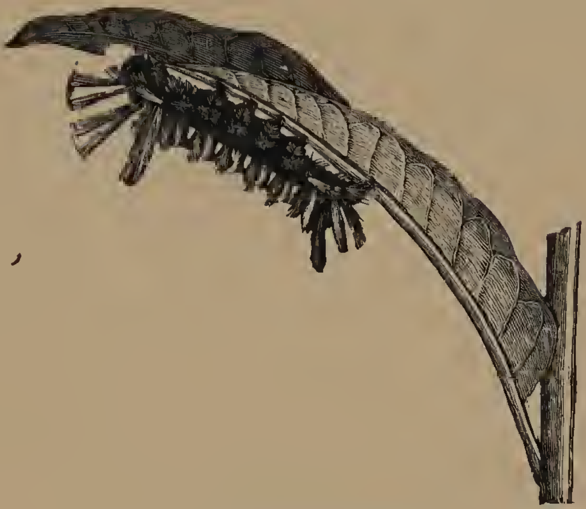


Fig. 424. — *Euchætias egle,* larva.

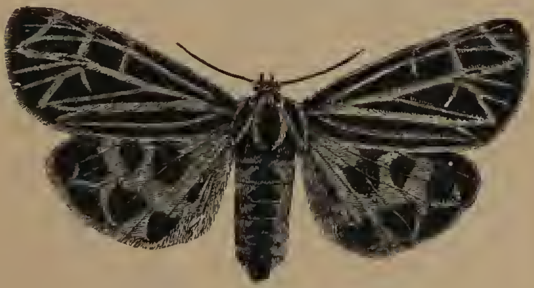


Fig. 425. — *Apantesis virgo.*

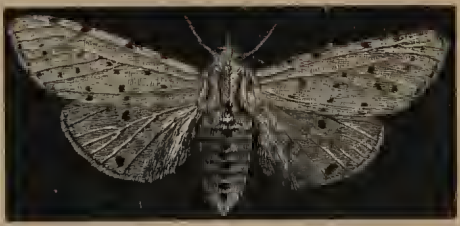


Fig. 426. — *Estigmene acræa.*

The salt-marsh caterpillar, *Estigmēne acræa.* — The popular name of this insect was given to it nearly a century ago, and was suggested by the fact that the salt-marsh meadows near Boston, were overrun and laid waste by swarms of the larvæ. But the name is misleading, as the species is widely distributed throughout the United States, and infests a great variety of grasses and garden crops. The moth (Fig. 426) is white, marked with yellow and black. There are many black dots on the wings, a row of black spots on the back of the abdomen, another row on the venter, and two rows on each side. The sexes differ greatly in the ground-color of the wings; in the female, this is white throughout; in the male, only the upper surface of the fore wings is white, the lower surface of the fore wings and the hind wings above and below being yellow. The number and size of the black spots on the wings vary greatly. There are usually more submarginal spots on the hind wings than represented in our figure.

The fall webworms, *Hyphăntria cūnea* and *Hyphăntria tĕxtor.* — A very common sight in autumn in the North and in midsummer in the South is large ugly webs enclosing branches of fruit or forest trees. These webs are especially common on apple and on ash; but the insects that make them infest more than one hundred kinds of trees. These webs differ from those made by the apple-tree tent-caterpillar in being much lighter in texture and in being extended over all of the leaves fed upon by the colony; and they are also made later in the year. Each web is the residence of a colony of larvæ which have hatched from a cluster of eggs laid on a leaf by the parent moth.

In the North the adults are all snow-white in color and there is only a single generation annually. This form is the *Hyphantria textor* of those who believe that there are two species.

In the South, some of the moths have the fore wings thickly studded with dark brown points, some are pure white, and every gradation exists between these two types. Of this southern form there are two generations annually. This form is known as *Hyphantria cunea.*

Both forms winter in the pupa state.

The Isabella tiger-moth, *Īsia isabĕlla.* — "Hurrying along like a caterpillar in the fall" is a common saying among country people in New England, and probably had its origin in observations made upon the larva of the Isabella tiger-moth. This is the evenly clipped, furry caterpillar reddish-brown in the middle and black at either end, which is seen so commonly in the autumn and early spring (Fig. 427). The extent of the black color varies in different individuals; rarely, the body is all brown. In the spring after feeding for a time the larva makes a blackish-brown cocoon composed largely of its hair. The adult is of a dull grayish tawny-yellow, with a few black dots on the wings, and frequently with the hinder pair tinged with orange-red. On the middle of the back of the abdomen there is a row of about six black dots, and on each side of the body a similar row of dots.

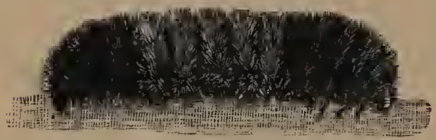


FIG. 427. — *Isia isabella*, larva.

The yellow-bear, *Diacrĭsia virgĭnica.* — The larva of this species is one of the most common hairy caterpillars found feeding on herbaceous plants. The long yellow hairs with which the body is clothed are uneven in length, some scattered ones being twice as long as the others. The long hairs are nowhere gathered into pencils as with the tussock-caterpillars. This larva varies greatly in color. The body is most often of a pale yellow or straw color, with a black, more or less interrupted, longitudinal line along each side, and a more or less distinct transverse line of the same color between each of the segments. Sometimes the hairs are foxy-red or light brown, and the body brownish or even dark brown. The head and the ends of the feet and fore legs are yellowish, and the venter is dusky. The larva feeds on almost any plant especially on the silk of corn. The cocoon is light, and is composed almost entirely of the hairs of the caterpillar. This insect passes the winter in the pupa state; and it is probable that there are usually two or more broods each year;

but these are not well marked. The moth (Fig. 428) is snowy-white, with the wings marked by a few black dots; these vary in number, but there are rarely more than three on either wing. There is a row of black spots on the back of the abdomen, and another on each side, and between these a longitudinal deep yellow stripe.

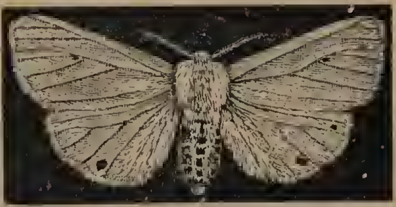


FIG. 428. — *Diacrisia virginica.*

The hickory tiger-moth, *Halysidōta cāryæ.* — One of the most abundant of caterpillars in the Atlantic States and westward during the months of August and September is one clothed with dense tufts of finely barbed white hairs (Fig. 429); there is a ridge or crest of black hairs on the middle of the back of the abdominal segments, a few long white hairs projecting over the head from the thorax, and others projecting back from the last segment; there are also two pairs of pencils of black hairs, one on the first and one on the seventh abdominal segment, and a similar pair of pencils of white hairs on the eighth abdominal segment. This larva feeds on hickory, butternut, and other forest-trees. Its grayish cocoons, composed almost entirely of the hair of the larva, are often found under stones, fences, and other similar places. The fore wings of the adult (Fig. 430) are dark brown spotted with white.

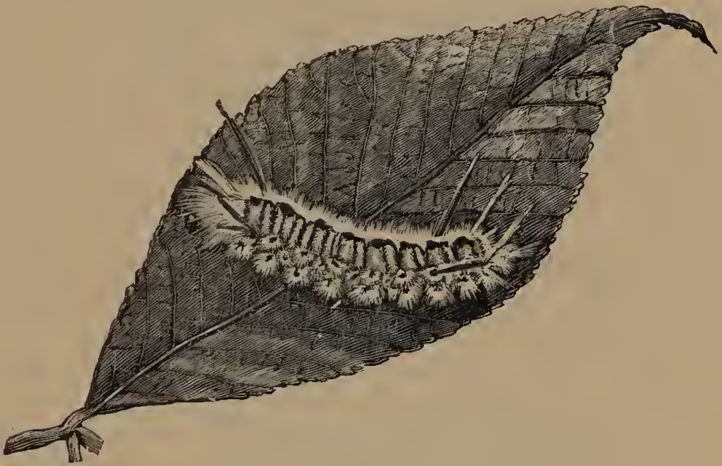


FIG. 429. — *Halysidota caryæ*, larva.

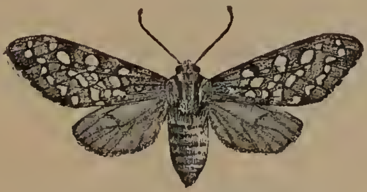


FIG. 430. — *Halysidota caryæ.*

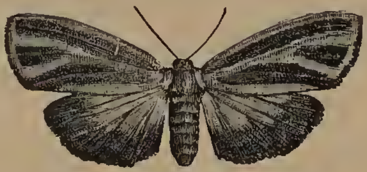


FIG. 431. — *Hypoprepia miniata.*

The striped footman, *Hypoprēpia miniāta.* — This beautiful moth is of a deep scarlet color, with three broad lead-colored stripes on the front wings. Two of the stripes extend the entire length of the wings; while the third is between these and extends from the end of the discal cell to the outer margin (Fig. 431). The outer half of the hind wings is also slate-colored. Vein M_2 of the fore wings is present; but Vein M_2 of the hind wings is wanting. The larva feeds upon lichens, and may be found under loose stones or on the trunks of trees. It is dusky, and thinly covered with stiff, sharp, and barbed black bristles, which grow singly from small warts. The cocoon is thin and silky.

The banded footman, *Illice unifasciāta.* — This little beauty occurs in the Atlantic States from New York to Texas. The fore wings are lead-colored, and crossed by a yellow band, which extends also along the inner margin to the base of the wings. The hind wings are pink except the apex, which is lead-colored. There is much variation in the width of the yellow band.

There are several closely allied species which are difficult to distinguish from this one.

Family CITHERONIIDÆ

The Royal-moths

The royal-moths are stout-bodied and hairy, with sunken heads and strong wings. The species are of medium or large size, some of them being nearly as large as the largest of our moths. In these moths the frenulum is lost and its place is taken by a greatly expanded humeral angle of the hind wing (Fig. 432, p. 285), which, projecting under the fore wing, insures the acting together of the two in flight without the aid of a frenulum. The antennæ of the males are broadly pectinated, but for only little more than half their length. The palpi and the maxillæ are very small.

The larvæ are armed with horns or spines, of which those on the second thoracic segment, and sometimes also those on the third, are long and curved. These caterpillars eat the leaves of forest trees, and go into the ground to transform, which they do without making cocoons. The rings of the pupa bear little notched ridges, the teeth of which, together with some strong prickles at the hinder end of the body, assist it in forcing its way upwards out of the earth.

This is a small family; it is not represented in Europe, and less than twenty species are known to occur in this country. The more common ones are the following.

The regal-moth *Citherōnia regālis.* — This is the largest and most magnificent of the royal-moths (Fig. 433). The fore wings are olive-colored, spotted with yellow, and with the veins heavily bordered with red scales. The hind wings are orange-red, spotted with yellow, and with a more or less distinctly marked olive band outside the middle. The wings expand from 4 to 6 inches.

When fully grown the larva measures from 4 to 5 inches in length. It is our largest caterpillar, and can be readily recognized by the very long spiny horns with which it is armed. Those of the mesothorax and metathorax are much longer than the others. Of these there are four on each segment; the intermediate ones measure about $\frac{3}{5}$ of an inch in length. This larva feeds on various trees and shrubs. It is known in some regions as the *hickory horned devil.*

The imperial-moth, *Basilōna imperiālis.* — This moth rivals the preceding species in size, expanding from 4 to $5\frac{1}{2}$ inches. It is sulphur-yellow, banded and speckled with purplish-brown. The full-grown larva

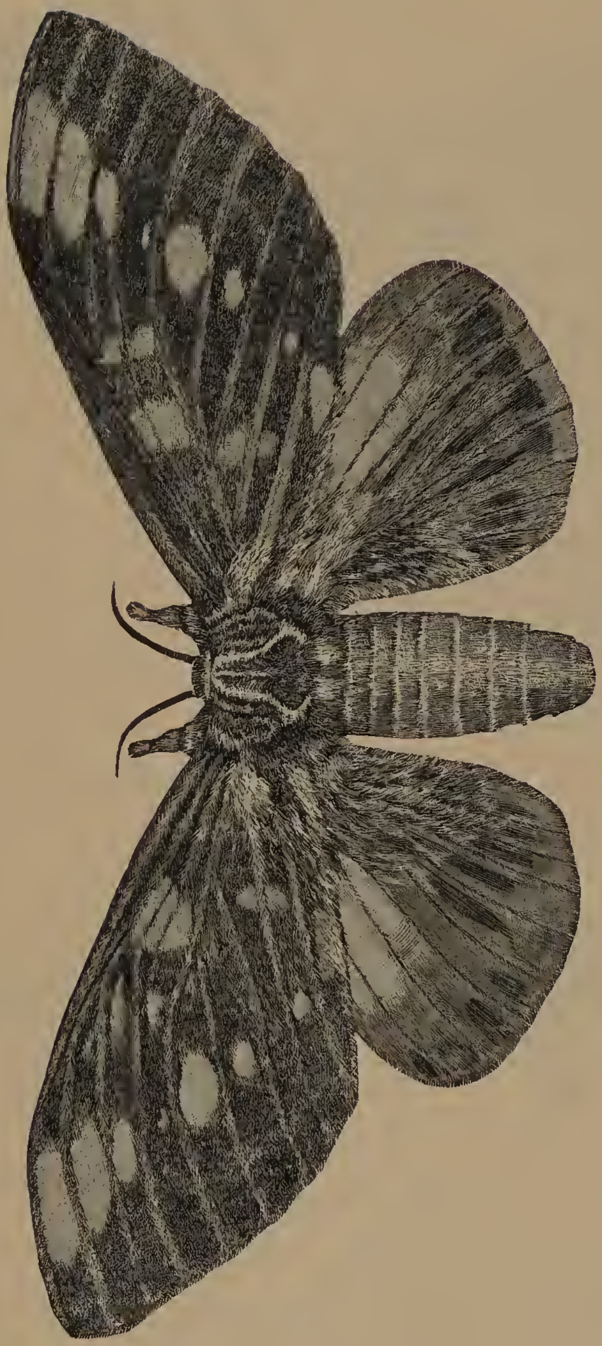


FIG. 433. — *Citheronia regalis.*

(Fig. 434) measures from 3 to 4 inches in length. It is thinly clothed with long hairs, and bears prominent spiny horns on the second and third thoracic segments. In the early larval stages these thoracic horns are very long and spiny, resembling those of the larva of the regal-moth.

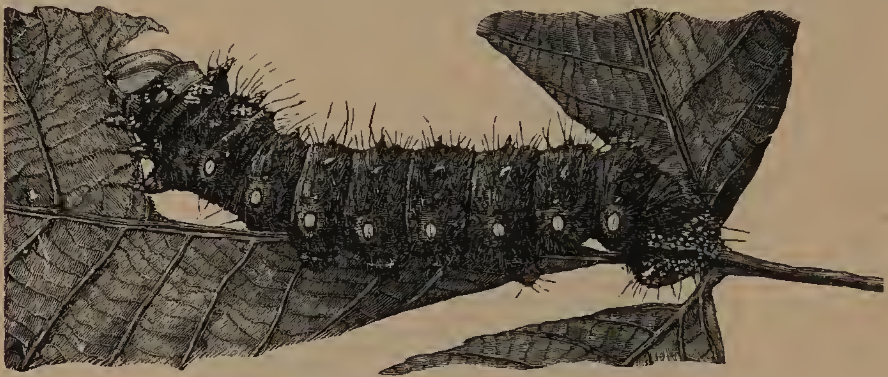


Fig. 434. — *Basilona imperialis*, larva

The larva feeds on hickory, pine, oak, butternut, and other forest trees.

The two-colored royal-moth, *Adelocĕphala bĭcolor*. — In this species the upper side of the fore wings and the underside of the hind wings are yellowish-brown, speckled with black. The underside of the fore wings and the upper side of the hind wings are to a considerable extent pink. There is usually a dark discal spot on the fore wings, upon which, especially in the males, there may be two white dots. This species is more common in the South than in the North. The expanse of wings in the male is 2 inches; in the female, 2⅖ inches. The larva feeds on the leaves of the honey-locust and of the Kentucky coffee-tree.

The rosy-striped oak-worm, *Anisōta virginiĕnsis*. — The wings of the female are purplish-red, blended with ochre-yellow; they are very thinly scaled, and consequently almost transparent; and are not speckled with small dark spots (Fig. 435). The wings of the male are purplish-brown, with a large transparent space on the middle (Fig. 436). The larva is of an obscure gray or greenish color, with dull brownish-yellow or rosy stripes, and with its skin rough with small white warts. There is a row of short spines on each segment, and two long spines on the mesothorax.

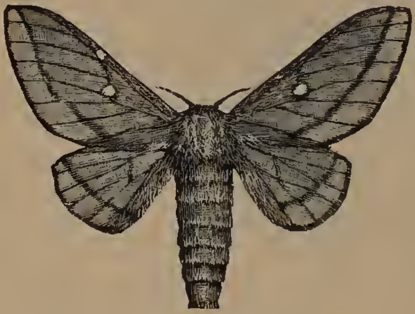


Fig. 435. — *Anisota virginiensis*, female

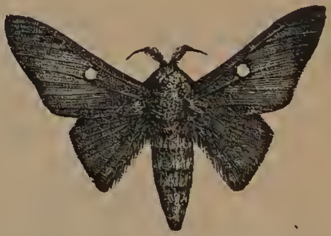


Fig. 436. — *Anisota virginiensis*, male.

The orange-striped oak-worm, *Anisōta senatōria*. — The wings of the female are more thickly scaled than in the preceding species and are sprinkled with numerous blackish dots; in other respects the two are quite similar in coloring. The male differs from that of *A. virginiĕnsis* in lacking the large transparent space on the middle of the wings. The larva is black, with four orange-yellow stripes on the back and two along each side; its spines are similar to those of the preceding species.

The spiny oak-worm, *Anisōta stĭgma.* — The female closely resembles that of *A. senatoria;* and as both species are variable it is sometimes difficult to determine to which a given specimen belongs. In *A. stigma* the wings are rather darker and have a greater number of blackish spots, and the hind wings are furnished with a middle band which is heavier and more distinct than in *A. senatoria.* The male differs from that of the other two species in quite closely resembling the female in coloring, and in having the wings speckled. The larva differs from the other species of *Anisota* in having long spines on the dorsal aspect of the third thoracic and each abdominal segment in addition to the much longer spines on the mesothorax. It is of a bright tawny or orange color, with a dusky stripe along its back and dusky bands along its sides.

The rosy Anisota, *Anisota rubicŭnda.* — The wings of this moth (Fig. 437) are pale yellow, banded with rose-color. The distribution of the color varies greatly in different specimens. In some the pink of the fore wings predominates, the yellow being reduced to a broad discal band, while in one variety the ground-color is yellowish-white and the pink is reduced to a shade at the base and a narrow stripe outside the middle. The hind wings may be entirely yellow, or may have a pink band outside the middle. The expanse of wings in the male is about $1\frac{1}{2}$ inches; in the female about 2 inches.

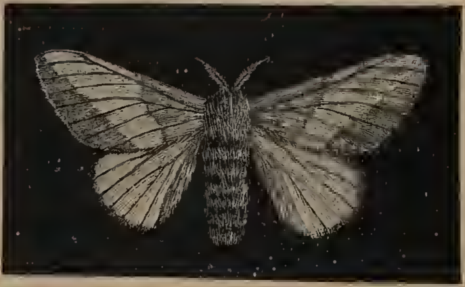


Fig. 437. — *Anisota rubicunda.*

The larva of this species is known as the green-striped maple-worm, and is sometimes a serious pest on soft-maple shade-trees. It measures when full grown about $1\frac{1}{2}$ inches. It is pale yellowish-green, striped above with eight very light, yellowish-green lines, alternating with seven of a darker green, inclining to black. There are two prominent horns on the second thoracic segment, and two rows of spines on each side of the body, one above and one below the spiracles. And on the eighth and ninth abdominal segments there are four prominent dorsal spines. The species is one- or two-brooded, and winters in the pupa state.

Family SATURNIIDÆ

The Giant Silk-worms

The large size of members of this family and the ease with which cocoons of some of the species can be collected render them well known to every beginner in the study of entomology. They are stout-bodied, hairy moths with more or less sunken heads and strong wide wings. The palpi are small, and the maxillæ but little developed, often vestigial. The sexes of these moths can be distinguished by the fact that the antennæ of the males are more broadly pectinated than are those of the females.

The family includes our largest lepidopterous insects and all of our species are above medium size.

The wings are often furnished with transparent, window-like spots. The frenulum is completely lost. The humeral angle of the hind wings is largely developed, and is usually strengthened by a deep furrow.

The larvæ of most of our species live exposed on the leaves of trees and shrubs; but some of them, as the New Mexico range-caterpillar, feed on grass. They are more or less armed with tubercles and spines and are very conspicuous on account of their large size. Most of them transform within silken cocoons, which are usually very dense, and in some cases have been utilized by man. These cocoons are often attached to trees and shrubs, and are sometimes inclosed in a leaf. They can be easily collected during the winter months, and the adults bred from them. The larvæ of some members of the family as *Hemileuca māia* enter the ground to transform.

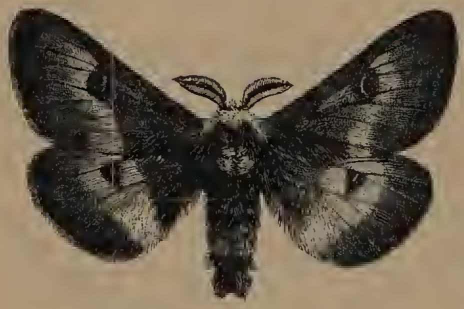


Fig. 438. — *Hemileuca maia.*

The maia-moth, *Hemileuca maia.* — The genus *Hemileuca* is represented in our fauna by eleven species, but only two of these are found in the East. In *maia* (Fig. 438) the wings are thinly scaled, sometimes semi-transparent; they are black with a common white band near their middle; and the discal veins are usually white and broadly bordered with black. There are great variations in the width of the white band on the wings. The larva feeds on the leaves of oak; it is brownish-black, with a lateral yellow stripe; and is armed on each segment with large, branching, venomous spines. The larva almost always enters the ground to transform.

The New Mexico range-caterpillar, *Hemileuca olĭviæ.* — Of the ten western species of *Hemileuca* this is doubtless of the greatest economic importance. It is a grass-feeding species, which has been very destructive in certain sections of the cattle-range in northeastern New Mexico. It was estimated that in 1809 the total infested area was at least 15,000 square miles, and that there were an average of 10 caterpillars to the square rod over this region. For a full account see U. S. Dept. Agr. Bull. No. 85, Part V.

The io-moth, *Autŏmeris io.* — This is a common species in the East. The female is represented by Figure 439. In this sex the ground-color of the fore wings is purplish-red. The male differs from the female in being somewhat smaller and of a deeper yellow color, but otherwise it resembles the female.

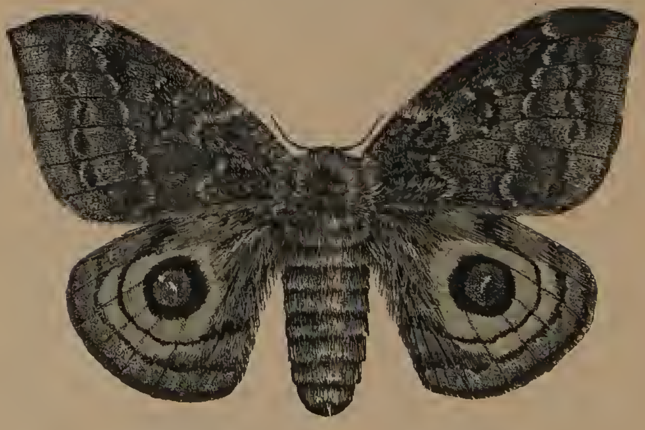


Fig. 439. — *Automeris io.*

The larva is one that the student should learn to recognize in order that he may avoid handling it; for it is armed with spines the prick of which is venomous (Fig. 440). The same is true of the larva of the maia-moth, but that is much less common. The larva of the io-moth is green, with a broad brown or reddish stripe, edged below with white, on each side of the abdomen. The spines are tipped with black. This larva feeds on various trees and shrubs.

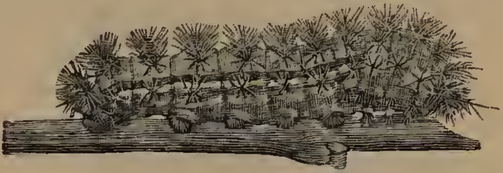


FIG. 440. — *Automeris io*, larva.

The polyphemus-moth, *Tēlea polyphēmus*. — This is a yellowish or brownish moth with a window-like spot in each wing. There is a gray band on the costal margin of the fore wings; and near the outer margin of both pairs of wings there is a dusky band, edged without with pink; the fore wings are crossed by a broken dusky or reddish line near the base, edged within with white or pink. The transparent spot on each wing is divided by the discal vein, and encircled by yellow and black rings. On the hind wings the black surrounding the transparent spot is much widened, especially toward the base of the wing, and is sprinkled with blue scales. The wings expand from 5 to 6 inches.

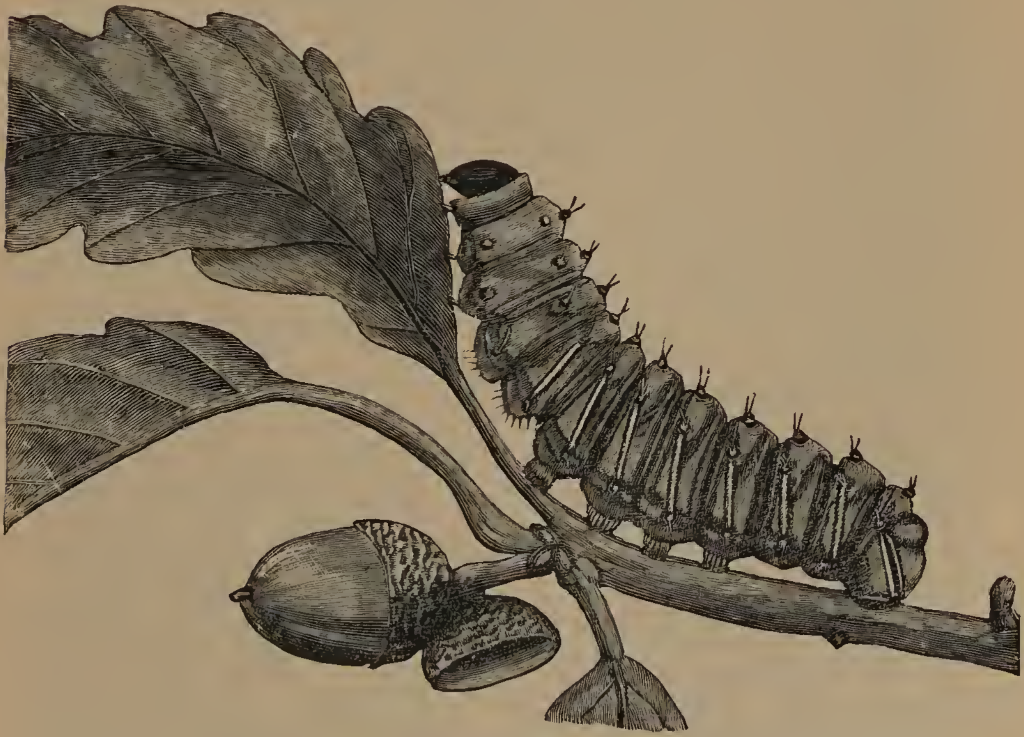


FIG. 441. — *Telea polyphemus*, larva.

The larva (Fig. 441) feeds on oak, butternut, basswood, elm, maple, apple, plum, and other trees. When full-grown it measures 3 inches or more in length. It is of a light green color with an oblique yellow line on each side of each abdominal segment except the first and last; the last segment is bordered by a purplish-brown V-shaped mark. The tubercles on the body are small, of a reddish color with metallic reflections. The cocoon (Fig. 442) is dense and usually enclosed in a leaf; it can be utilized for the manufacture of silk. When the adult is ready to emerge, it excretes a fluid which softens the cocoon at one end, and breaking the threads by means of a pair of stout spines, one on each side of the thorax at the base of the fore wings, it makes its exit through a large round hole.

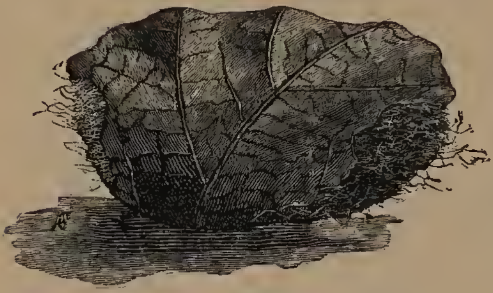


Fig. 442. — Cocoon of *Telea polyphemus*.

The Luna-moth, *Tropæa luna.* — This magnificent moth (Fig. 443) is a great favorite with amateur collectors. Its wings are of a delicate light green color, with a purple-brown band on the costa of the fore wings; there is an eye-like spot with a transparent center on the discal vein of each wing; and the anal angle of the hind wings is greatly prolonged. The larva feeds on the leaves of walnut, hickory, and other forest-trees. It measures when full-grown about 3 inches in length. It is pale bluish green with a pearl-colored head. It has a pale yellow stripe along each

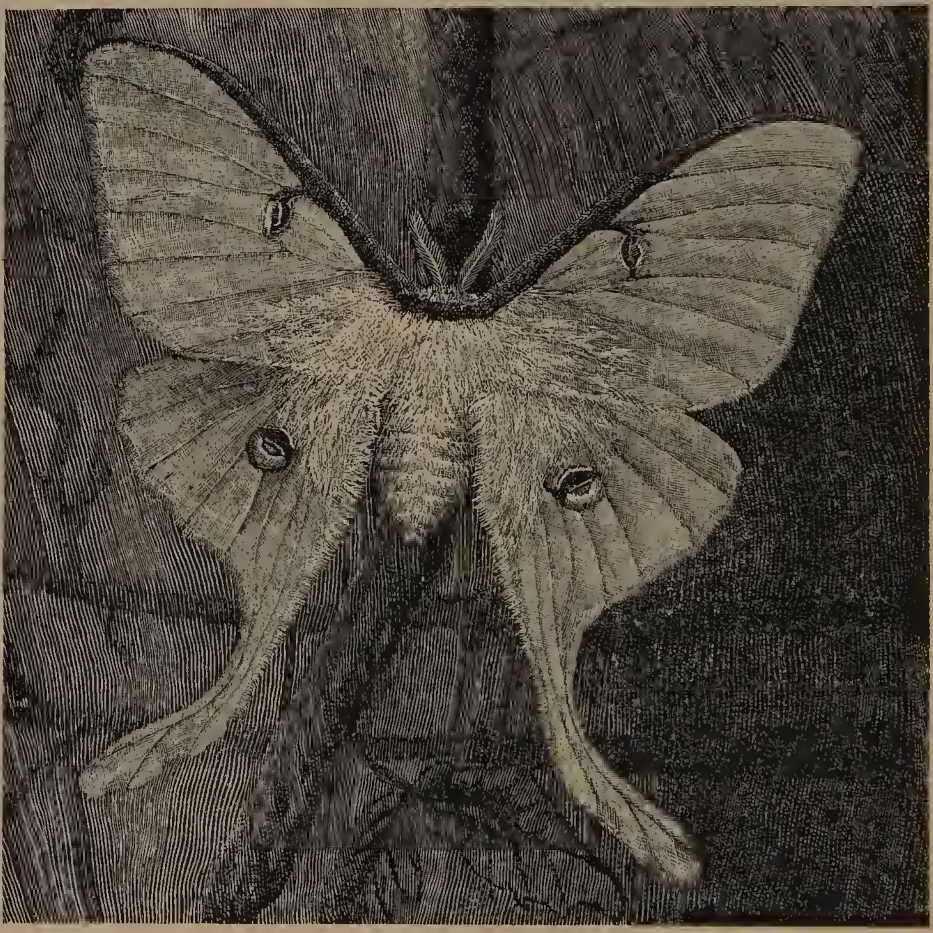


Fig. 443. — *Tropæa luna.*

side of the body, and a transverse yellow line on the back between each two abdominal segments. The cocoon resembles that of the preceding species in form, but is very thin, containing but little silk.

The promethea-moth, *Callosāmia promēthea.* — This is the most common of the giant silk-worms. The wings of the female (Fig. 444) are light reddish-brown; the transverse line crossing the middle of the wings is whitish, bordered within with black; the outer margin of the wings is clay-colored, and each wing bears an angular discal spot. The discal spots vary in size and distinctness in different specimens. The male differs so greatly from the female that it is liable to be mistaken for a distinct species. It is blackish, with the transverse lines very faint, and with the discal spots wanting or very faintly indicated. The fore wings also differ markedly in shape from those of the female, the apex being much more distinctly sickle-shaped. The males fly by day. The larva when full-grown measures 2 inches or more in length. It is of a clear pale bluish-green color; the legs and anal shield are yellowish; and the body is armed with longitudinal rows of tubercles. The tubercles are black, polished, wart-like elevations, excepting two each on the second and third thoracic segments, which are larger and rich coral-red, and one similar in size to these but of a yellow color on the eighth abdominal segment. This larva feeds on the leaves of a large proportion of our common fruit and forest-trees; but we have found it more frequently on wild cherry, lilac, tulip-tree, ash, and sassafras than on others. The cocoons can be easily collected during the winter from these trees. This is the best way to obtain fresh specimens of the moths, which will emerge from the cocoons in the spring or early summer. The cocoon (Fig. 445) is interesting in structure. It is greatly elongated and is enclosed in a leaf, the petiole of which is securely fastened to the branch by a band of silk extending from the cocoon; thus the leaf and enclosed cocoon hang upon the tree throughout the winter. At the upper end of the cocoon there is a conical valve-like arrangement which allows the adult to emerge without the necessity of making a hole through the cocoon. This structure is characteristic of the cocoons of the moths of this and the following genus.

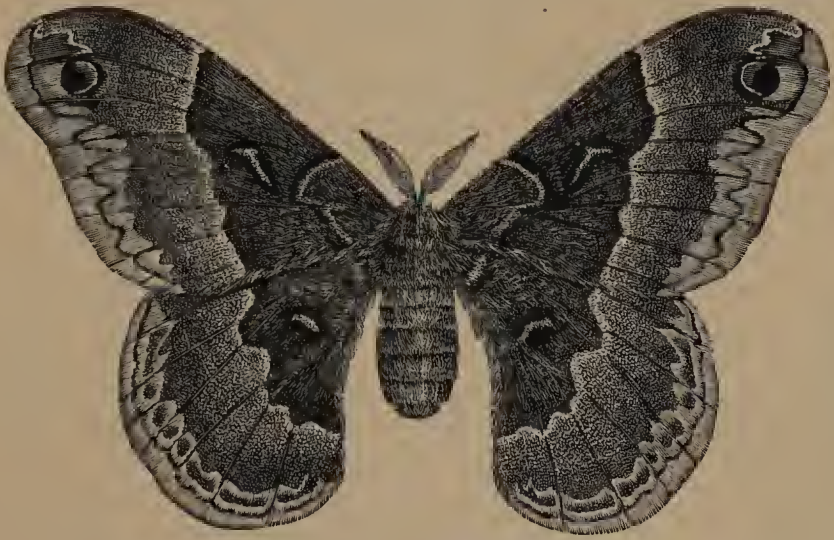


FIG. 444. — *Callosamia promethea,* female.

The angulifera-moth, *Callosāmia angulĭfera*. — This is a somewhat rare insect which closely resembles the promethea-moth. Specimens of it are usually a little larger than those of *C. promethea*, and the transverse line and discal spots are more angular. The most important differences, however, are presented by the male, which quite closely resembles the female of the promethea-moth in color and markings, and thus differs decidedly from the male of that species. The male of this species is nocturnal, differing in this respect from *C. promethea*.

The larva feeds on the leaves of the tulip-tree and of magnolia. It makes its cocoon within a leaf or it crawls down the trunk of the tree and spins its cocoon in the grass or fastens it to some object on the ground. The cocoon usually has no stem and when made in a leaf falls to the ground in it when the leaf falls.

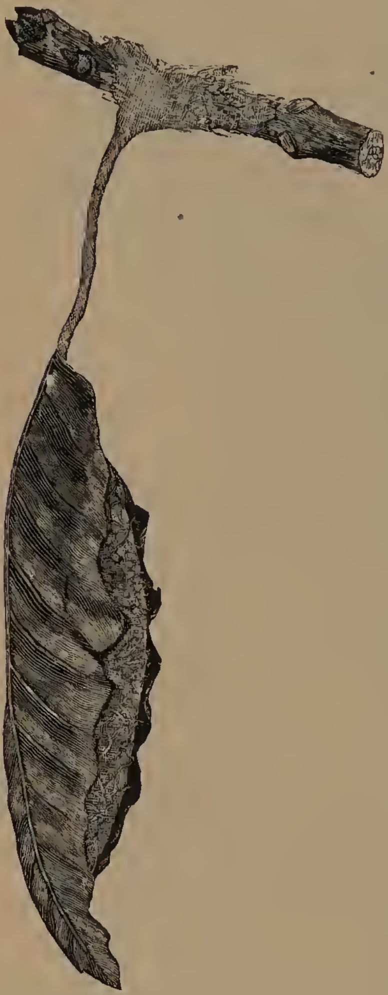


FIG. 445. — *Callosamia promethea*, cocoon.

The cecropia-moth, *Sāmia cecrōpia*. — This is the largest of our giant silk-worms, the wings of the adult expanding from 5 to $6\frac{2}{5}$ inches. The ground color of the wings is a grizzled dusky brown, especially on the central area. The wings are crossed beyond the middle by a white band, which is broadly margined without with red, and there is a red spot near the apex of the fore wing just outside of a zigzag line. Each wing bears near its center a crescent-shaped white spot bordered with red. The outer margin of the wings is clay-colored. The larva is known to feed on at least fifty species of plants, including apple, plum, and the more common forest-trees. When full-grown it measures from 3 to 4 inches in length and is dull bluish-green in color. The body is armed with six rows of tubercles, extending nearly its entire length, and there is an additional short row on each side of the ventral aspect of the first five segments following the head. The tubercles on the second and third

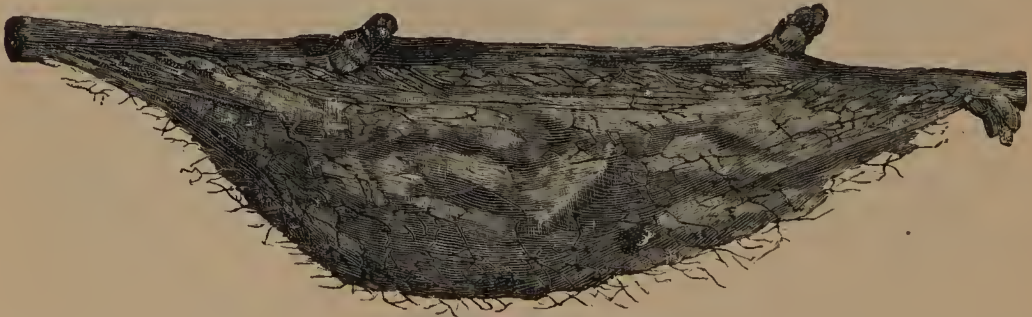


FIG. 446. — *Samia cecropia*, cocoon.

thoracic segments are larger than the others, and are coral-red. The other dorsal tubercles are yellow, excepting those of the first thoracic and last abdominal segments, which with the lateral tubercles are blue; all are armed with black bristles. The cocoon is represented by Figure 446.

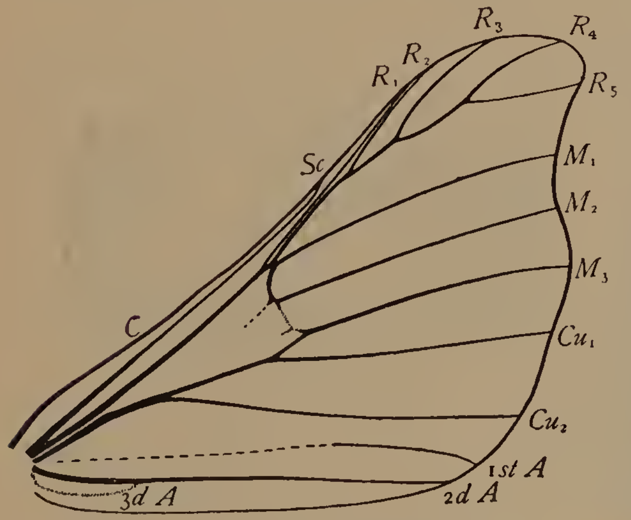
The ailanthus-worm, *Philosāmia walkeri.* — This is an Asiatic species which has been introduced into this country. It has become a pest in the vicinity of New York City, where it infests the Ailanthus shade-trees. The moth differs from all our native species of this family in having rows of tufts of white hairs on the abdomen. Its cocoon resembles that of the promethea-moth. The specific identity of this species is in doubt.

Family Bombycidæ

The Silk-worm

The family Bombycidæ is not represented in our fauna; but a single species, the silk-worm, is frequently bred in this country, and is usually present in collections of Lepidoptera.

The silk-worm, *Bombyx mori.* — The moth (Fig. 447) is of a cream-color with two or three more or less distinct brownish lines across the fore wings and sometimes a faint double bar at the end of the discal cell. The head is small; the antennæ are pectinated broadly in both sexes; and the ocelli, palpi, and maxillae are wanting. A striking feature of the venation of the wings (Fig. 448) is the obvious presence of the base of vein R_1 in the hind wings.



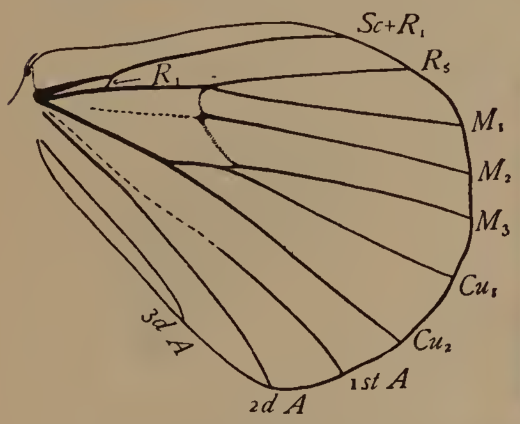


Fig. 448. — Wings of *Bombyx mori.*

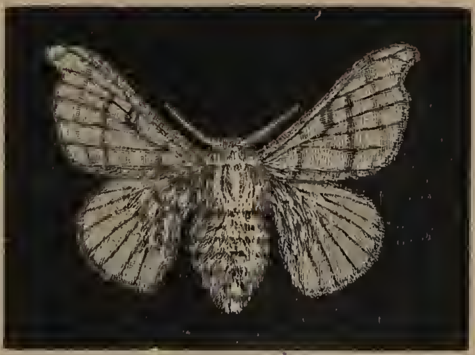


Fig. 447. — *Bombyx mori.*

The usual food of the silk-worms is the leaf of the mulberry. Our native species, however, are not suitable. The species that are most used are the white mulberry (*Morus alba*) of which there are several varieties, and the black mulberry (*Morus nigra*); the former is the better. The leaves of osage orange (*Maclura aurantiaca*) have also been used as silk-worm food to a considerable extent. In case silk-worms hatch in the spring before either mulberry or osage-orange leaves can be obtained, they may be quite successfully fed, for a few days, upon lettuce-leaves.

The newly-hatched larva is black or dark-gray, and is covered with long stiff hairs, which spring from pale-colored tubercles. The hairs and tubercles are not noticeable after the first molt, and the worm becomes lighter and lighter, until in the last larval period it is of a cream-white color. There is a prominent tubercle on the back of the eighth abdominal segment, resembling those borne by certain larvæ of the Sphingidæ.

There are many special treatises on this insect, some of which should be consulted by any one intending to raise silk-worms.

Family LASIOCAMPIDÆ

The Lasiocampids

The best-known representatives of this family are the tent-caterpillars and the lappet-caterpillars. The adults are stout-bodied, hairy moths of medium size. The antennæ are pectinated in both sexes, and from one-fourth to one-half as long as the front wings; the teeth of the antennæ of the male are usually much longer than those of the female. The ocelli

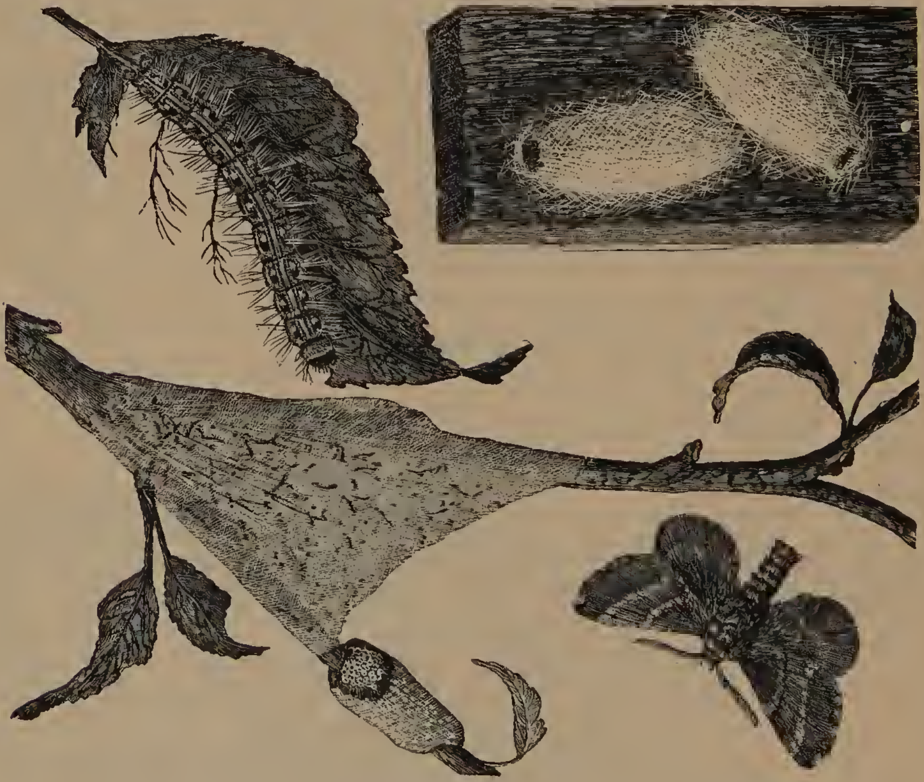


FIG. 449. — *Malacosoma americana*, eggs, tent, larva, cocoons, and adult.

and the maxillæ are wanting; and the palpi are usually short and woolly. But the most distinct characteristic is found in the wings. The frenulum is wanting, there being instead, as in the giant silkworm moths a largely expanded humeral angle of the hind wings.

The larvæ of the Lasiocampidæ feed upon the foliage of trees, and are frequently very destructive.

Less than thirty North American species are known.

The apple-tree tent-caterpillar, *Malacosōma americāna.* — This insect builds large webs in apple and wild cherry trees in early spring. Figure 349 represents its transformations. The moth is dull reddish-brown, with two transverse whitish or pale yellowish lines on the fore wing. The figure represents a male; the female is somewhat larger. These moths appear early in the summer. The eggs are soon laid, each female laying all her eggs in a single ring-like cluster about a twig; and here they remain unhatched for about nine months. This cluster is covered with a substance which protects it during the winter. The eggs hatch in early spring, at the time or just before the leaves appear. The larvæ that hatch early feed upon the unopened buds till the leaves expand. The larvæ are social, the entire brood that hatch from a cluster of eggs keeping together and building a tent in which they live when not feeding. The larvæ leave the nest daily in order to feed; and spin a silken thread wherever they go. The larvæ become full-grown early in June; one of them is represented on a partially-eaten leaf in the figure. When ready to transform they leave the trees and make their cocoons in some sheltered place. These cocoons are quite peculiar in appearance, having a yellowish-white powder mixed with the silk. The pupa state lasts about three weeks.

Another species of the genus *Malacosōma* found in the East is the so-called forest tent-caterpillar, *Malacosōma dĭsstria.* The range of this species extends throughout the United States and Canada. It differs from the preceding species in that the larvæ do not construct a true tent. It feeds on the leaves of many forest and fruit-trees, but maple is its favorite food-plant. In other respects its life history is quite similar to that of the apple-tree tent-caterpillar. The moth differs from *M. americana* in having the oblique lines on the wings dark instead of light; the larva differs in having a row of spots along the back instead of a continuous narrow line; the egg-masses differ in ending squarely instead of being rounded at each end; and the cocoon is more fragile, with less powder, and distinctly double.

The Great Basin tent-caterpillar, *Malacosōma frăgilis.* — This species is found throughout the northern portions of the Great Basin, extending from the Rocky Mountains to the Cascades and Sierra Nevadas, and has been found in California. It feeds on *Ceanothus* and many other wild shrubs.

The California tent-caterpillar, *Malacosōma califŏrnica*, feeds normally on oak but also attacks fruit-trees. The caterpillars are orange-colored and about 1 inch long.

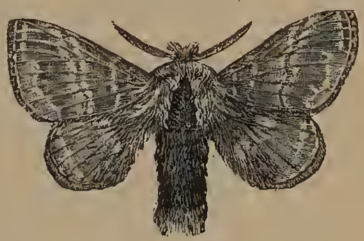


Fig. 450. — *Tolype velleda.*

The velleda lappet, *Tŏlype vĕlleda.* — The body of the moth is milk-white, with a large blackish spot on the middle of its back (Fig. 450). That part of this spot which is on the thorax is composed of erect scales, the caudal part of recumbent hairs. The wings are dusky gray, crossed by white lines as shown in the figure. The figure represents the male; the female is much larger. The moths are found in August and September. The larva feeds upon the leaves of apple, poplar, and syringa. Its body is bluish-gray, with many faint longitudinal lines; and across the back of the last thoracic segment there is a narrow velvety-black band. The larva reaches maturity during July. The cocoon is brownish-gray, and is usually attached to one of the branches of the tree on which the larva has fed.

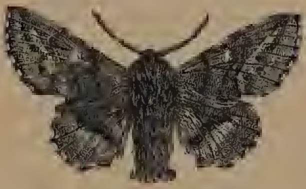


FIG. 451. — *Epicnaptera americana.*

The American lappet, *Epicnăptera americāna.* — This species is found from the Atlantic to the Pacific. It is somewhat variable, and the different varieties were formerly regarded as distinct species. The moth (Fig. 451) is reddish-brown, with the inner angle of the front wings and the costal margin of the hind wings deeply notched. Beyond the middle of each wing there is a pale band edged with zigzag, dark brown lines. The larva lives upon apple, cherry, oak, birch, maple, and ash. When full-grown it measures 2⅖ inches in length and ½ inch in breadth. The upper side is slate-gray, mottled with black, with two transverse scarlet bands, one on the second and one on the third thoracic segments. There is a black spot on each end and in the middle of each of these bands. The larva is found during July and August. It is said that the cocoons are attached to limbs like those of *Tolype;* but the larvæ of this species that we have bred made their cocoons between leaves, or in the folds of the muslin bag enclosing the limb upon which they were feeding. The species passes the winter in the pupa state; and the moth appears in June, when it lays its eggs upon the leaves of the trees it infests.

THE SKIPPERS

The skippers are so-called on account of their peculiar mode of flight. They fly in the daytime and dart suddenly from place to place. When at rest most species hold the wings erect in a vertical position like butterflies; in many the fore wings are thus held while the hind wings are extended horizontally; and a few extend both pairs of wings horizontally. The head is wide; the antennæ are widely separated; they are thread-like, and enlarged toward the tip; and in most cases the extreme tip is pointed and recurved, forming a hook. The abdomen is usually stout, resembling that of a moth rather than that of a butterfly.

Family MEGATHYMIDÆ

The Giant Skippers

This family includes a small number of large skippers, which are found in the South and far West. In the adult insect the head is of moderate size, the width, including the eyes, being much less than that of the metathorax. The club of the antennæ is large; and, although the tip is turned slightly to one side, it is neither drawn out to a point nor recurved. The body is very robust. These insects fly in the daytime and with a rapid, darting, flight. When at rest they fold their wings in a vertical position.

So far as is known the larvæ in the later stages of their growth are borers in the stems and roots of various species of *Yucca* and *Agave* and the larvæ spin silken tubes between the young and tender shoots of these plants.

Megathȳmus strĕckeri (Fig. 452) will serve as an example of the giant skippers. The specimen figured is a female of the variety known as *texana*.

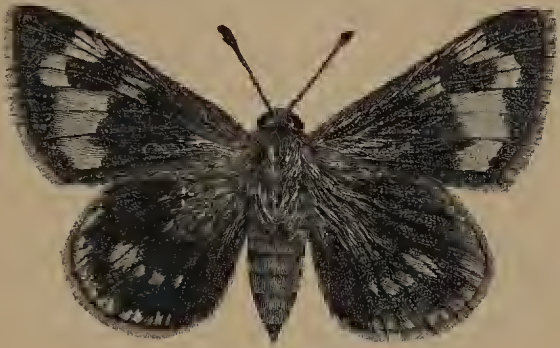


Fig. 452. — *Megathymus streckeri.*

A much better known species is the yucca-borer, *Megathȳmus yŭccæ.* — The female of this species differs from that of the preceding in having much darker wings, all of the spots being smaller, and in having only one or two white spots on the lower surface of the hind wings. The male lacks the erect hairs on the hind wings. The larva bores in the stem and root of the Yucca or Spanish bayonet. It differs greatly in appearance from the larvæ of the Hesperiidæ, having a small head. This species is widely distributed through the southern part of our country.

Family Hesperiidæ

The Common Skippers

This family includes all of our skippers except the very small number that belong to the preceding family, the giant skippers.

The larvæ of the common skippers present a very characteristic appearance, having large heads and strongly constricted necks (Fig. 453). They usually live concealed in a folded leaf or in a nest made of several leaves fastened together. The pupæ are rounded, not angular, resembling those of moths more than those of butterflies. The pupa state is passed in a slight cocoon, which is generally composed of leaves fastened together with silk, and thinly lined with the same substance.

One group in this family is known as the *skippers with a costal fold.* The males of many of these forms have a fold in the fore wing near the costal margin which forms a long slit-like pocket containing a sort of silky down. This structure forms a scent-organ, and the pocket is known as the *costal fold.* It is not present in all of the species.

These skippers are of both moderate and rather large size. Most are dark brown marked with white or translucent angular spots. The antennæ usually have a long club which is bent at a considerable distance from the tip.

The silver-spotted skipper, *Epargȳreus tĭtyrus.* — This is one of the largest of our common skippers, having a wing-expanse of nearly or quite 2 inches. It is dark chocolate-brown, with a row of yellowish spots extending across the fore wing and with a large silvery-white spot on the lower side of the hind wing (Fig. 454). It is found in nearly the whole United States and in southern Canada. The larva (Fig. 453) feeds upon various papilionaceous plants. It is common on locust. It makes a nest, within which it remains concealed, by fastening together, with silk, the leaflets of a compound leaf (Fig. 455). This is one of the very few skippers that winter in the pupa state; most species winter as larvæ, either partly grown or in their cocoons.

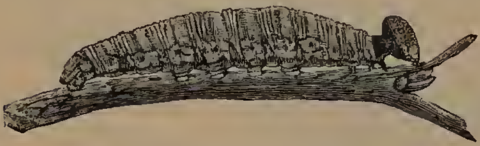


Fig. 453. — *Epargyreus tityrus*, larva.

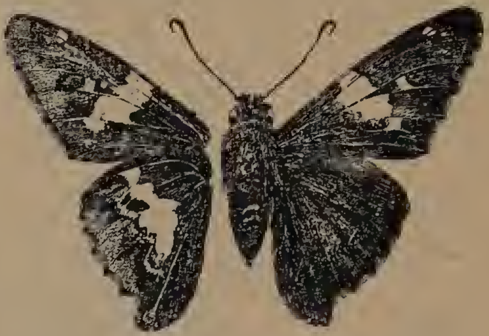


Fig. 454. — *Epargyreus tityrus;* under surface at left. (From Scudder.)

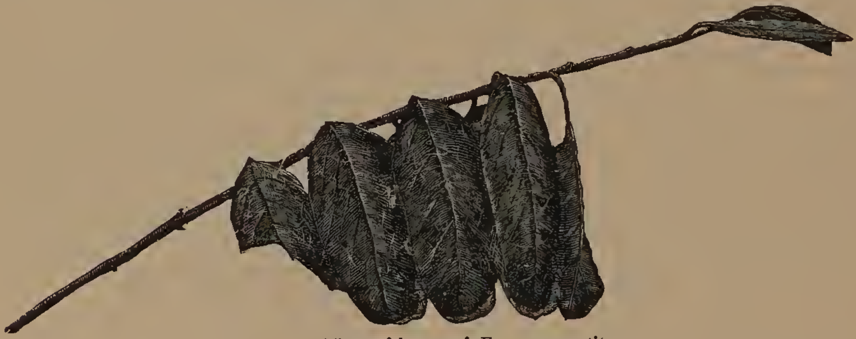


Fig. 455. — Nest of larva of *Epargyreus tityrus.*

The bean leaf-roller, *Goniūrus prōteus.* — This skipper by the shape of its wings reminds one of a swallow-tail butterfly, the hind wings being furnished with long tails. It expands about 1$\frac{3}{5}$ inches and the greatest length of the hind wings is about 1$\frac{1}{5}$ inches. The wings are very dark chocolate-brown. The front wings contain several silvery-white spots; and the body and base of the wings bear metallic-green hairs. The larvæ feed upon both Leguminosæ and Cruciferæ. In the South it is sometimes a pest in gardens, cutting and rolling the leaves of beans, turnips, and cabbage, and feeding within the rolls thus formed. It is found on the Atlantic border from New York southward into Mexico.

The northern cloudy-wing, *Thŏrybes pȳlades.* — This is a common skipper with dark brown wings. The fore wings are flecked with tiny white spots while the hind wings are crossed beneath by two rather narrow, parallel, inconspicuous, dark bands. The species is found in nearly all parts of the United States. The larva commonly feeds on clover.

The genus *Hesperia* includes a considerable number of small skippers, which are easily recognized by their checkered markings of white upon a dark brown ground. In this genus the white spots are unusually large, so large in some cases that they occupy the greater part of the wing. One of the more common species is the variegated tessellate, *Hespĕria tessellāta*. This is distributed from the Atlantic to the Pacific and is the only one common in the Eastern United States. In this species more than one-half of the outer two-thirds of both fore and hind wings is white.

A second group of skippers in this family is known as the *skippers with a brand*. It includes the greater number of our small skippers as well as some which are of fairly large size. All of our tawny skippers together with some black and dark brown species belong here. The antennæ usually have a stout club with a short recurved tip, the latter sometimes wanting.

In the majority of our species the males can be recognized at a glance by a conspicuous patch crossing the disk of the fore wings, which usually appears to the naked eye like a scorched, oblique streak, and which on this account is termed the *brand* (Fig. 456). The brand is a complicated organ, composed of tubular scales, the androconia, that are the outlets of scent-glands, and of other scales of various shapes; in some species the brand is wanting.

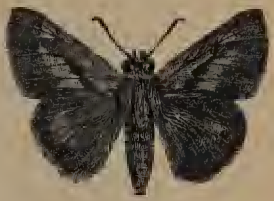


FIG. 456. — *Atrytone conspicua.*

This subfamily is an exceedingly difficult one to study. One hundred and twenty-five species have been described from America north of Mexico; and in many cases the differences between allied species are not well marked. The following two are named merely as examples. The first one is easily recognized.

The least skipper, *Ancylŏxyipha nūmitor.* — This skipper is the smallest of our common species, and is also remarkable for lacking the recurved hook at the tip of the antennæ. The wings are tawny, broadly margined with dark brown. In some specimens the fore wings are almost entirely brown. The larger individuals expand about 1 inch. The larva feeds upon grass in damp places.

The black-dash, *Atrȳtone conspĭcua.* — The male of this species is represented by Figure 456. It is blackish-brown with considerable yellow on the basal half of the fore wings. The brand is velvety black. This species is distributed from Massachusetts to Nebraska.

THE BUTTERFLIES

The butterflies differ from moths in that they have clubbed antennæ, fly only in the daytime (except some species in the tropics), hold the wings erect above the back when at rest, and have no frenulum. Some moths present one or more of these characteristics, but no moth presents all of them. Butterflies can be distinguished from skippers by the venation of the front wings.

Among the many works treating of American butterflies the two following are especially useful for the classification of our species, each of these works is illustrated by many full-page plates representing the insects in their natural colors: "How to Know the Butterflies, A Manual of the Butterflies of the Eastern United States" by J. H. and A. B. Comstock, and "The Butterfly Book, A Popular Guide to a Knowledge of the Butterflies of North America" by W. J. Holland.

The butterflies found in America north of Mexico represent five families.

Family Papilionidæ

The Swallow-tails and the Parnassians

This family includes the swallow-tail butterflies, which are common throughout our country, and the parnassians, which are found only on high mountains or far north. These insects are distinguished from all other butterflies found in our fauna by the fact that vein M_2 of the fore wings appears to be a branch of cubitus, making this vein appear to be four-branched, and by the fact that the anal area of the hind wings is more reduced than the anal area of the fore wings, the former containing only a single anal vein, the latter two in the parnassians and three in the swallow-tails.

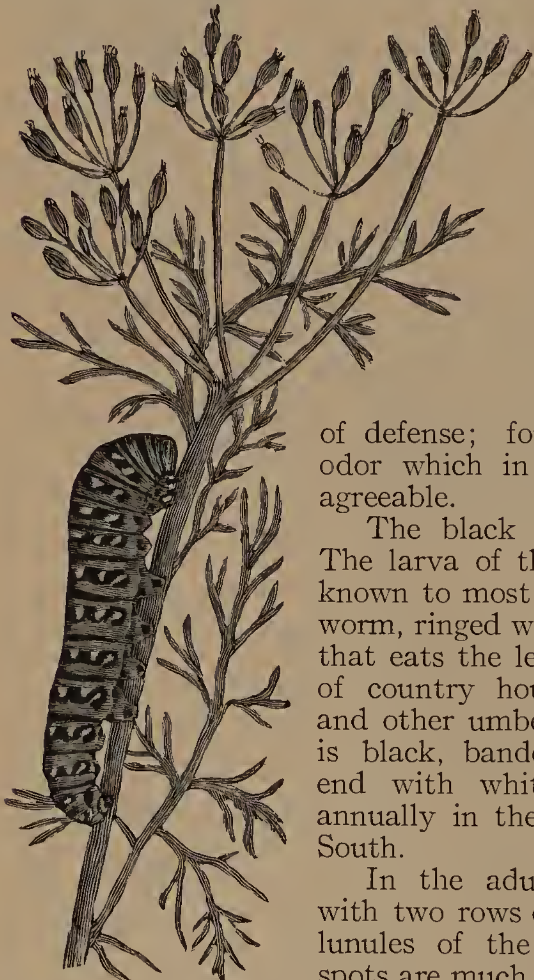


Fig. 457. — *Papilio polyxenes*, larva.

The caterpillars are never clothed with spines but are either naked or clothed with a few fine hairs. In at least one species in our fauna, the body bears fleshy filaments.

A striking peculiarity of the larvæ of this family is the presence of a bright-colored, forked, horn-like process which can be projected from a slit in the dorsal wall of the prothorax. This is the *osmeterium* which is an organ of defense; for it exhales when pushed out an odor which in some species is exceedingly disagreeable.

The black swallow-tail, *Papĭlio poly̆xenes.* — The larva of this swallow-tail (Fig. 457) is well-known to most country children. It is the green worm, ringed with black and spotted with yellow, that eats the leaves of caraway in the back yards of country houses. It feeds also on parsnips and other umbelliferous plants. The young larva is black, banded about the middle and caudal end with white. There are two generations annually in the North and at least three in the South.

In the adult the wings are black, crossed with two rows of yellow spots, and with marginal lunules of the same color. The two rows of spots are much more distinct in the male than in the female, the inner row on the hind wing forming a continuous band crossed with black lines on the veins. Between the two rows of spots on the hind wings there are many blue scales; these are more abundant in the female. Near the anal angle of the hind wing there is an orange spot with a black center. On the lower surface of the wings the yellow markings become mostly orange and are heavier.

This species is found throughout the United States and in the southern parts of Canada. In California the black swallow-tail is replaced as a celery and parsley pest by a related species, *Papilio zolĭcaon.*

The tiger swallow-tail, *Papilio glaucus.* — The larva of this butterfly (Fig. 458) is even more striking in appearance than that of the preceding species. When full-grown it is dark green, and bears on each side of the third thoracic segment a large greenish-yellow spot, edged with black, and enclosing a small black figure 10. This caterpillar has the curious habit of weaving upon a leaf a carpet of silk, upon which it rests when not feeding; when nearly full-grown, instead of spinning a simple carpet as before, it stretches a web across the hollow of a leaf and thus makes a spring bed upon which it sleeps (Fig. 458).

The larva of this species feeds on birch, poplar, ash, wild cherry, fruit-trees, and many other trees and shrubs.

In the adult state two distinct forms of this insect occur. These differ so greatly in appearance that they were long considered distinct species. They may be distinguished as follows.

(1) The turnus form, *Papilio glaucus turnus.* — The wings are bright straw-yellow above, and pale, faded straw-yellow beneath, with a very broad black outer margin, in which there is a row of yellow spots. On the fore wings there are four black bars, extending back from the costa; the inner one of these crosses the hind wings also. This form is represented by both sexes, and is found in nearly all parts of the United States and Canada.

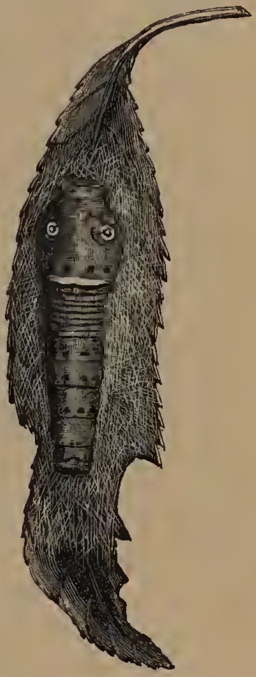


Fig. 458. — *Papilio glaucus,* larva upon its bed.

(2) The glaucus form, *Papilio glaucus glaucus.* — In this form the disk of the wings is entirely black, but the black bands of the turnus form are faintly indicated, especially on the lower surface, by a darker shade. The marginal row of yellow spots is present, and also the orange spots and blue scales of the hind wings. This form is represented only by the female sex, and occurs only in the more southern part of the range of the species, i.e., from Long Island to Montana and southward. It was the first of the two forms to be described, hence the species bears the name *glaucus.*

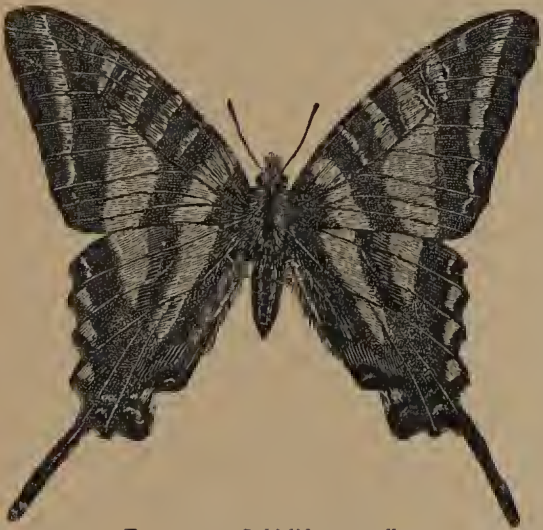


Fig. 459. — *Iphiclides marcellus.*

The zebra swallow-tail, *Iphiclīdes marcĕllus.* — This butterfly (Fig. 459) differs from all other swallow-tails found in the eastern half of the United States in having the wings crossed by several bands of greenish-white. This is one of the most interesting of our butterflies, as it occurs under three distinct forms, two of which were considered for a long time distinct species. Without taking into account the more minute differences, these forms can be separated as follows.

(1) The early-spring form, *Iphiclides marcellus marcellus.* — This is the form figured here. It expands from 1$\frac{3}{5}$ to 2$\frac{4}{5}$ inches; and the tails of the hind wings are about $\frac{3}{5}$ of an inch in length and tipped with white.

(2) The late-spring form, *Iphiclīdes marcĕllus telamŏnides.* — This form is a little larger than the early spring form and has tails nearly one-third longer; these tails are bordered with white on each side of the distal half or two-thirds of their length.

(3) The summer form, *Iphiclīdes marcĕllus lecŏntei.* — The summer form is still larger expanding from 3$\frac{1}{5}$ to 3$\frac{1}{2}$ inches, and has tails nearly two thirds longer than the early spring form.

The life history of this species has been carefully worked out by Mr. W. H. Edwards. He has shown that there are several generations each year, and that the winter is passed in the chrysalis state. But the early-spring form and the late-spring form are not successive broods; these are both composed of individuals that have wintered as chrysalids, those that emerge early developing into *marcellus marcellus*, and those that emerge later developing into *marcellus telamonides*. All of the butterflies produced from eggs of the same season, and there are several successive broods, are of the summer form, *marcellus lecontei*.

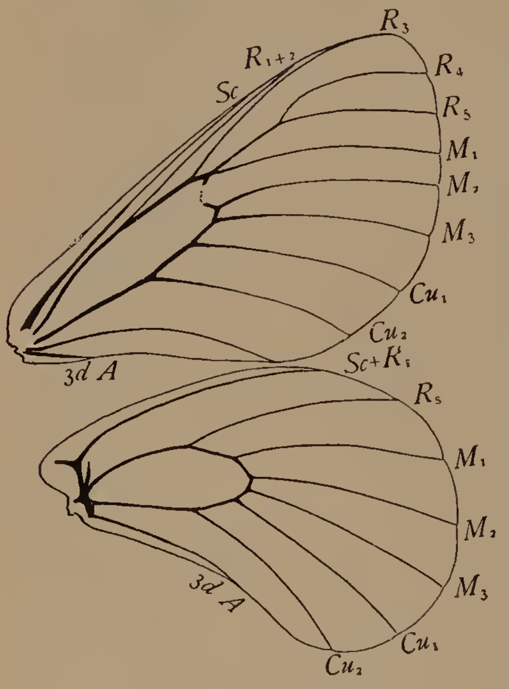


FIG. 460. — Wings of *Parnassius.*

The larva feeds upon papaw (*Asimina*). This insect is found through out the eastern half of the United States except in the extreme north.

The *parnassians.* — They are butterflies of medium size in which the ground color of the wings is white shaded with black, and marked with round red or yellow spots margined with black.

In structure the parnassians are closely allied to the swallow-tails; but in their general appearance they show little resemblance to them, differing in the ground color of the wings, and in lacking the tail-like prolongations of the hind wings in all of our species.

In the venation of the wings (Fig. 460) they differ from the swallow-tails in that radius of the fore wings is only four-branched and the first anal vein is wanting. They agree with the swallow-tails and differ from all other butterflies in that the cubitus of the fore wings is apparently four-branched.

The larvæ possess osmeteria similar to those of the larvæ of swallow-tails. When about to pupate the larva either draws a leaf or leaves about its body by a few threads or it merely hides under some object on the ground. The pupa is cylindrical and rounded, not angulate like those of swallow-tails.

Only four species have been found in North America; they all belong to the genus *Parnăssius*. Of the four species, two are Alaskan; the others occur in the mountains of the Pacific States, in Wyoming, and in the Rocky Mountains. Of each of the two latter there are several named varieties.

Family PIERIDÆ

The Piĕrids

These butterflies are usually of medium size, but some of them are small; they are nearly always white, yellow, or orange, and are usually marked with black. They are the most abundant of all our butterflies, being common everywhere in fields and roads. Some species are so abundant as to be serious pests, the larvæ feeding on cultivated plants.

In this family the fore legs are well developed in both sexes, there being no tendency to their reduction in size, as in the three following families.

The larvæ are usually slender green worms clothed with short, fine hairs; the well-known cabbage-worms are typical illustrations (Fig. 461). The chrysalids are supported by the tail and by a girth around the middle. They may be distinguished at a glance by the presence of a single pointed projection in front (Fig. 461).

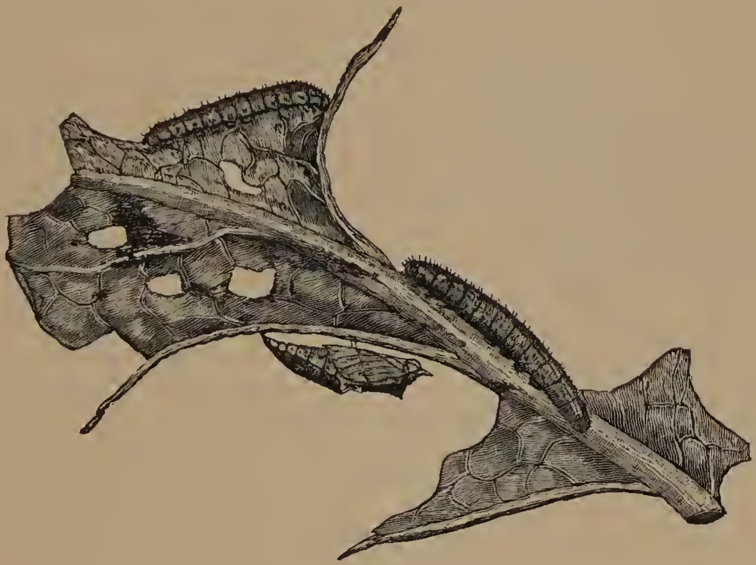


FIG. 461. — *Pieris rapæ*, larva and pupa.

Our genera of this family can be separated into three groups, which seem hardly distinct enough to be ranked as subfamilies. These are the whites, the yellows and the orange-tips.

THE WHITES

The more common representatives of this group are the well-known cabbage-butterflies. They are white butterflies more or less marked with black. Occasionally the white is tinged with yellow; and sometimes yellow varieties of our white species occur. About a dozen North American species of this group are known.

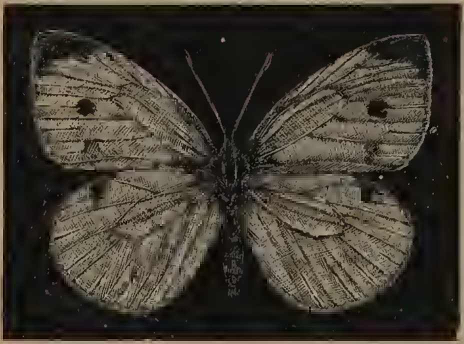


Fig. 462. — *Pieris rapæ.*

The cabbage-butterfly, *Pīeris rāpæ.* — The wings of this butterfly are dull white above, occasionally tinged with yellowish, especially in the female; below, the apex of the fore wings, and the entire surface of the hind wings are pale lemon yellow. In the female there are two spots on the outer part of the fore wing besides the black tip, in the male only one (Fig. 462).

There is considerable variation in the intensity of the black markings, and in the extent of the yellow tinge of the wings.

The larva of this species (Fig. 461) feeds principally on cabbage, but it also attacks many other cruciferous plants. Its color is the green of the cabbage-leaf, with a narrow, greenish, lemon-yellow dorsal band, and a narrow, interrupted stigmatal band of the same color. The body is clothed with very fine short hairs.

Pīeris rāpæ is without doubt the most injurious to agriculture of all our species of butterflies. It is an introduced species, but has spread over the greater part of this country. As it is three-brooded in the North and more in the South, it is present nearly the entire season, so that it needs to be fought constantly.

The checkered white, *Pīeris protŏdice.* — The two sexes of this species differ greatly in appearance, the female being much more darkly marked than the male. The wings are white, marked above with grayish-brown. There is a bar of this color at the end of the discal cell; beyond this there is in the male a row of three more or less distinct spots, and in the female an almost continuous band of spots. Besides these there is in the female a row of triangular spots on the outer margin of both fore and hind wings, and on the hind wings a submarginal zigzag bar.

The larva of this species is colored with alternating stripes of bright golden yellow and dark greenish-purple, upon which are numerous black spots. It feeds upon cabbage and other cruciferous plants, and occurs in nearly the whole of the United States.

THE ORANGE-TIPS

These, like the butterflies comprising the preceding group, are white, marked with black. Their most characteristic feature is the presence on the lower surface of the hind wings of a greenish network, or a marbled green mottling. This usually shows through the wing so as to appear as a dark shade when the wings are seen from above (Fig. 463). Many species have a conspicuous orange spot on the apical portion of the front wings. This has suggested the common name *orange-tips* for the group. But it should be remembered that some species lack this mark, and that in some others it is confined to the males. Most of our species are western. The two following occur in the East.

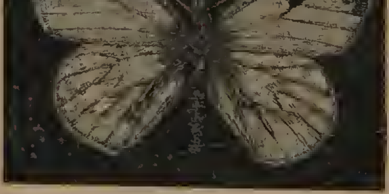


Fig. 463. — *Euchlœ ausonides.*

The falcate orange-tip, *Anthŏcharis genūtia.* — In this species the apex of the fore wings is hooked, reminding one of the hook-tip moths. In the males there is a large apical patch. This butterfly is found throughout the southeastern part of the United States, not including Florida. It occurs as far north as New Haven, Conn. It is nowhere abundant. The larva feeds on rock-cress, bitter cress, shepherd's purse, *Sisymbrium*, and other Cruciferæ that are slender in form.

The olympia orange-tip, *Sy̆nchlœ oly̆mpia.* — In this species the orange patch is wanting in both sexes. There is a conspicuous black bar at the end of the discal cell of the fore wings, and the apical portion of these wings is gray including a large irregular white band.

The larva is striped lengthwise with pale slate color and bright yellow; the feet, legs, and head are grayish-green. It feeds on hedge-mustard and other Cruciferæ.

THE YELLOWS

The yellows are easily recognized by their bright yellow colors, although in some species whitish forms occur. They abound almost everywhere in open fields, and are common about wet places in roads. To this group belong the larger number of our pierids.

The roadside butterfly or the clouded sulphur, *Eurymus philŏdice.* — The wings above are rather pale greenish-yellow, with the outer borders blackish-brown. Figure 464 represents the male; in the female the border on the fore wings is broader, and contains a sub-marginal row of yellow spots. The discal dot of the fore wings is black, that of the hind wings is orange. The under surface is sulphur-yellow.

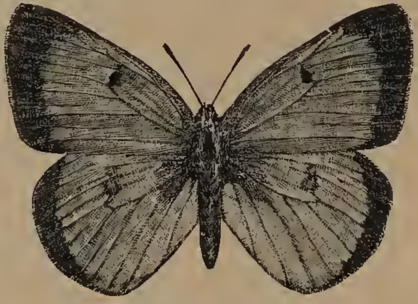


Fig. 464. — *Eurymus philodice.*

This species is dimorphic. The second form is represented only by the female sex, and differs in having the ground-color of the wings white instead of yellow.

This butterfly often occurs in large numbers in muddy places in country roads, for this reason it may be known as the roadside butterfly. It is also known as the clouded sulphur. Its range extends from the mouth of the St. Lawrence to South Carolina and westward to the Rocky Mountains. Its larva feeds upon clover and other Leguminosæ.

The orange sulphur, *Eurymus eury̆theme.* — This species closely resembles the preceding one in size, shape and markings. The typical form differs from *E. philodice* in being of an orange color above instead of yellow. This butterfly is found chiefly in the Mississippi Valley and west to the Pacific Ocean; it is also found in the Southwestern States, and occurs very rarely north to Maine. It is one of the most polymorphic of all butterflies; the forms differ so much in appearance that four or five of them have been described as distinct species. The larva feeds on clover and allied plants, and is sometimes a pest in alfalfa fields.

The dog's head, *Zerēne cæsōnia.* — The wings are lemon-yellow above bordered on the outer margin with black. On the hind wings the border is narrow, but on the fore wings it is broad. The outline of the yellow of the fore wings suggests a head of a dog or of a duck, a prominent black spot on the discal vein serving as the eye. This is an abundant species in the southeastern and southwestern states, extending from the Atlantic to the Pacific. The larva feeds on clover.

The little sulphur, *Eurēma eutĕrpe.* — Although this species is considerably below the average size of our yellows, the larger individuals expand about $\frac{3}{4}$ of an inch. The wings are canary-yellow above, with the apex of the fore wings and the outer margin of both fore and hind wings blackish-brown. The border of the hind wings is narrow and sometimes wanting. There is a red-brown splash on the apex of the hind wings below.

The distribution of this species is from New England to Florida and westward to Lower California. The larva feeds on *Cassia.*

The cloudless sulphur, *Catopsĭlia eubūle.* — This large butterfly differs greatly in appearance from those described above. It expands $2\frac{1}{2}$ inches. The wings above are of uniform bright canary-yellow. In the male they are without spots, except frequently an inconspicuous brown dot at the tip of each vein, and a lilac-brown edging of the costal border. In the female there is a discal dot on the fore wings and a marginal row of brown spots at the ends of the veins.

This is a southern species which occasionally extends as far north on the coast as New York City, and in the Mississippi Valley as far as southern Wisconsin. The larva feeds on *Cassia.*

Family Nymphalidæ

The Four-footed Butterflies

The family Nymphalidæ, includes chiefly butterflies of medium or large size, but a few of the species are small. With a single exception,. *Hypatus*, these butterflies differ from all others in our fauna in having the fore legs very greatly reduced in size *in both sexes.* So great is the reduction that these legs cannot be used for walking, but are folded on the breast like a tippet.

This is the largest of the families of butterflies. It not only surpasses the other families in number of species, but it contains a greater number and variety of striking forms, and also a larger proportion of the species of butterflies familiar to every observer of insects. There may be in any locality one or two species of yellows or of whites more abundant, but the larger number of species commonly observed are four-footed butterflies.

THE FRITILLARIES

The fritillaries are butterflies varying from a little below to somewhat above medium size. The color of the wings is fulvous, bordered and checkered with black, but not so heavily bordered as in the next subfamily. The lower surface of the wings is often marked with curving rows of silvery spots. The common name fritillary was suggested by the spotted coloration of these butterflies.

In the larvæ there is an even number of rows of spines on the abdomen, due to the fact that there are none on the middle of the back. The larvæ feed upon the leaves of violets.

There are many species of fritillaries, about fifty occur in America north of Mexico, and it is difficult to separate the closely allied species.

The great spangled fritillary, *Argy̆nnis cy̆bele.*—This species (Fig. 465) will serve to illustrate the appearance of the larger members of this group, those belonging to the genus *Argynnis*. In this genus vein R_2 of the fore wings arises before the apex of the discal cell.

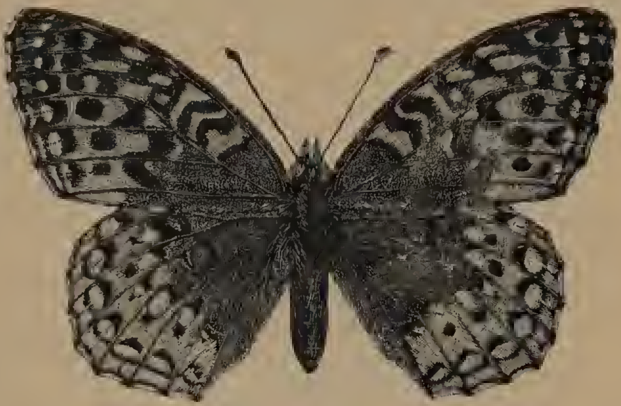


Fig. 465. — *Argynnis cybele.*

There are a number of common fritillaries which resemble the preceding in color and markings but which are much smaller, the wings expanding considerable less than 2 inches. These belong to the genus *Brenthis*. In this genus vein R_2 of the fore wings arises beyond the apex of the discal cell.

The variegated fritillary, *Euptoieta claudia.* — This butterfly agrees with the smaller fritillaries (*Brenthis*) in the origin of vein R_2 of the fore wing beyond the apex of the discal cell, but differs from them in the shape of the fore wing, the apex of which is much more produced (Fig. 466) and the outer margin, except at the apex, concave; it is also considerably larger.

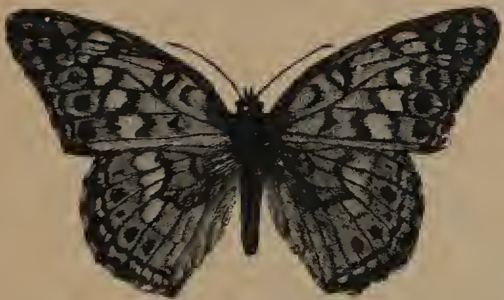


Fig. 466. — *Euptoieta claudia.*

This species occurs throughout the United States east of the Rocky Mountains; but is very rare in the northern half of this region. The larva feeds on the passion-flowers.

THE CRESCENT-SPOTS

This group includes some of the smaller members of the Nymphalidæ. The color of the wings is sometimes black, with red and yellow spots; but it is usually fulvous, with the fore wings broadly margined, especially at the apex, with black, and crossed by many irregular lines of black.

In the larva there is an odd number of rows of spines on the abdomen, due to the presence of spines on the middle of the back of some of the abdominal segments.

Sixty-three species of crescent-spots have been described from America north of Mexico; but nearly all of these are restricted to the far West.

The baltimore, *Euphydryas phāeton.* — The wings are black above, with an outer marginal row of dark reddish-orange spots, and two parallel rows of very pale yellow spots; on the fore wings a third row is more or less represented. The wings expand 2 inches or more.

The larvæ feed on a species of snakehead, *Chelone glabra;* they are gregarious in the fall and build a common nest in which they pass the winter; but separate after hibernation. They are very striking in appearance. The head and first two thoracic segments are shining black and the last three abdominal segments are black with two orange bands around each. All the other segments have a ground color of orange with various narrow transverse lines of black. This species occurs in Ontario and the northern half of the United States east of the Rocky Mountains. It is very local, the butterflies remaining near the bogs or moist meadows where the food-plant of the larva is found.

THE ANGLE-WINGS

To this group belong many of our best-known butterflies; there are twenty-five species in our fauna. With these the outer margin of the fore wings is usually decidedly angular or notched as if a part had been cut away. A large proportion of the species hibernate in the adult state, and some of them are the first butterflies to appear in the spring. Some of the hibernating species, however, remain in concealment till quite late in the season.

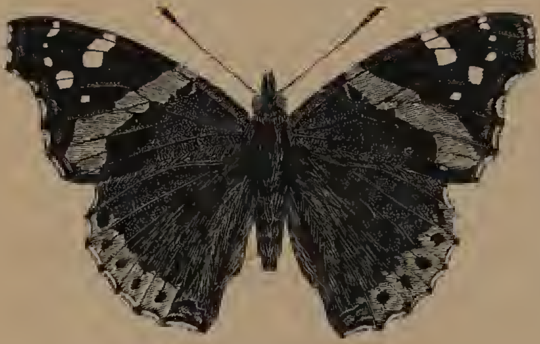


FIG. 467. — *Vanessa atalanta.*

The red admiral, *Vanĕssa atalănta.* — The wings are purplish-black above. On the fore wing there is a bright orange-colored band beginning near the middle of the costa, and extending nearly to the inner angle; between this and the apex of the wing are several white spots as shown in Figure 467; on the hind wing there is an orange band on the outer margin inclosing a row of black spots.

The larva feeds chiefly on elm, nettle, and hop. When first hatched it folds together a half-opened leaf at the summit of the plant; when larger it makes its nest of a lower expanded leaf. There are two broods; both butterflies and chrysalids hibernate. This butterfly occurs over nearly the whole of the European and North American continents.

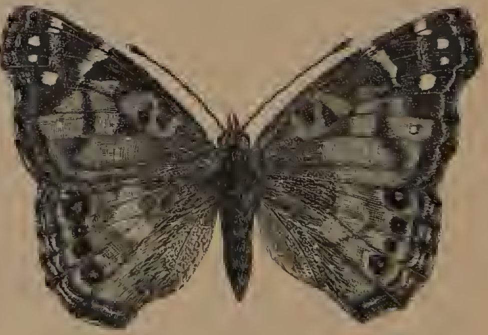


FIG. 468. — *Vanessa virginiensis.*

The painted beauty, *Vanĕssa virginiĕnsis.* — Figure 468 represents the upper side of this butterfly. The darker parts of the wings are very dark brownish black, the lighter parts a golden orange, sometimes with a pinkish tinge. In the apical portion of the fore wings there are several white spots as shown in the figure; the largest of these, the proximal one, is salmon or flesh-colored in the female. A characteristic feature of this species is the presence of *two* submarginal eye-like spots on the lower side of the hind wings. The larva feeds on everlasting (*Antennaria*) and allied plants. This species occurs from Canada to South America.

The painted beauty has been commonly known in this country as *Vanessa huntera;* but *Vanessa virginiensis* is the older name.

The cosmopolite, *Vanĕssa cărdui.* — The butterfly resembles the preceding very closely in color and markings. There is however, a smaller proportion of orange markings; and on the lower surface of the hind wings there is a submarginal row of *four* or *five* eye-like spots.

The larva feeds upon Compositæ, especially thistles. This species is very remarkable for its wide distribution. Mr. Scudder states "with the exception of the arctic regions and South America it is distributed over the entire extent of every continent."

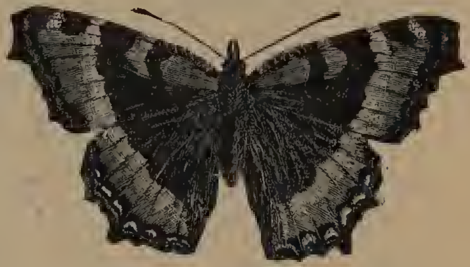


Fig. 469. — *Aglais milberti.*

The American tortoise-shell, *Aglais milbĕrti.* — The wings above are brownish-black, with a broad orange-fulvous band between the middle and the outer margin. There are two fulvous spots in the discal cell of the front wings (Fig. 469). The larvæ feed on nettle (*Urtica*) and are gregarious in habits. This species occurs in the northern portions of the United States and in Canada.

The mourning-cloak, *Euvanĕssa antīopa.* — The wings above are purplish-brown, with a broad yellow border on the outer margin sprinkled with brown, and a submarginal row of blue spots. The upper surface is represented by Figure 470, the lower by Figure 471, 5.

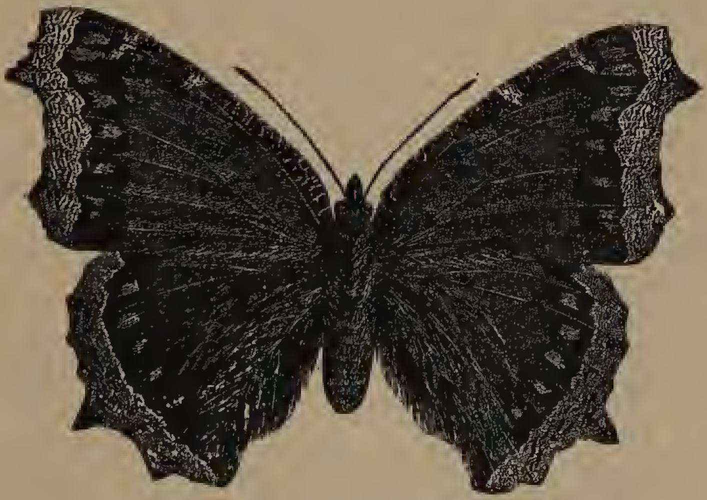


Fig. 470. — *Euvanessa antiopa.*

The larvæ live on willow, elm, poplar and *Celtis;* they are gregarious, and often strip large branches of their leaves. The species is usually two-brooded. "This butterfly is apparently distributed over the entire breadth of the Northern Hemisphere below the Arctic Circle as far as the thirtieth parallel of latitude." (*Scudder.*)

The compton tortoise, *Eugōnia j-ălbum.* — This butterfly (Fig. 472) resembles in its general appearance those of the genus *Polygonia*, but it is sharply distinguished from them by the inner margin of the fore wings being nearly straight, by the heavier markings of the fore wings, and by

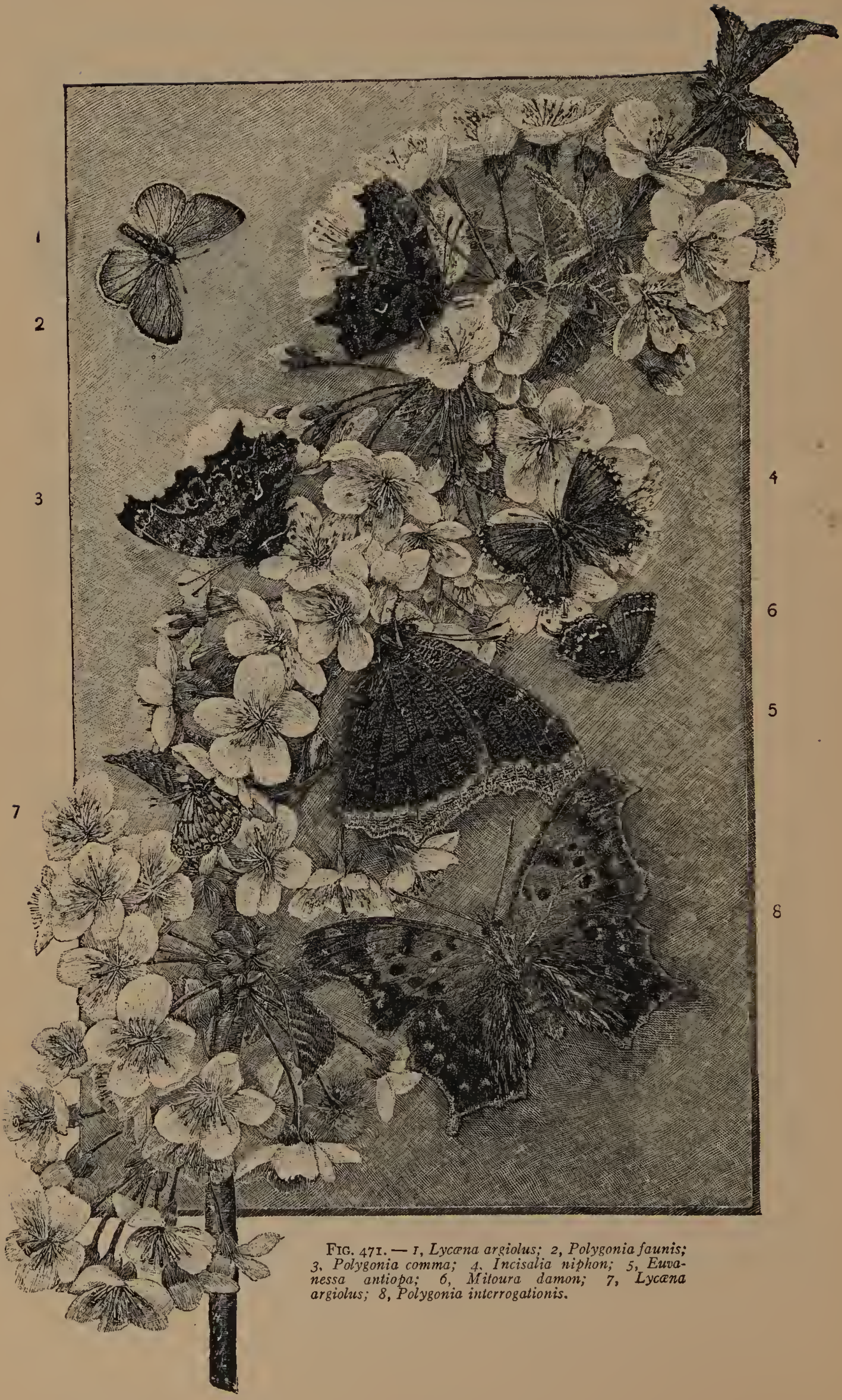


FIG. 471. — 1, *Lycæna argiolus*; 2, *Polygonia faunis*; 3, *Polygonia comma*; 4, *Incisalia niphon*; 5, *Euvanessa antiopa*; 6, *Mitoura damon*; 7, *Lycæna argiolus*; 8, *Polygonia interrogationis*.

the presence of a whitish spot on both fore and hind wings, near the apex, and between two larger black patches. On the lower surface of the hind wings there is a small L-shaped silvery bar. This species occurs throughout Canada and the northern portion of the United States east of the Rocky Mountains. It is double-brooded.

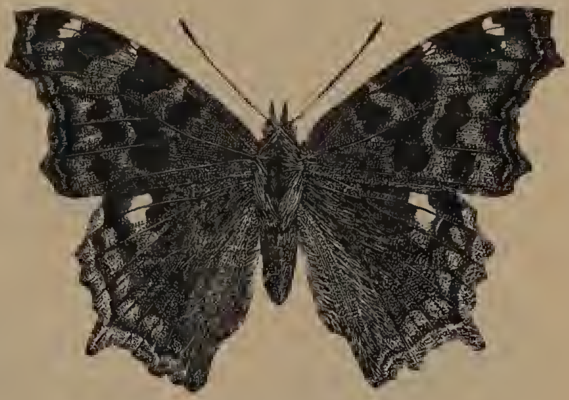


FIG. 472. — *Eugonia j-album.*

Polygōnia. — The butterflies of this genus resemble the preceding species in having a metallic spot on the lower surface of the hind wings, but differ in having the inner margin of the fore wings roundly notched beyond the middle.

Ten species occur in this country. These differ principally in the coloring and markings of the under surface of the hind wings. The following are some of the more common ones.

The green comma, *Polygōnia faunus.* — The silvery mark of the hind wings is usually in the form of a C or a G, the ends being more or less expanded (Fig. 471, 2) but sometimes it is reduced to the form of an L. The lower surface of the wings is more greatly variegated than in any other species of this genus; and there is a larger amount of green on this surface than in any other of the eastern species, there being two nearly complete rows of green spots on the outer third of each wing.

The larva feeds upon black birch, willow, currant, and wild gooseberry. This is a Canadian species; but it is also found in the mountains of New England and of New York, and in the northern portions of the western states, extending as far south as Iowa. It is single-brooded.

The hop-merchant, *Polygōnia cŏmma.* — As in the preceding species, the silvery mark of the hind wings is in the form of a C or a G (Fig. 471, 3) but the general color of the lower surface of the hind wings is very different, being marbled with light and dark brown; and the green spots so characteristic of *faunus* are represented here by a few lilaceous scales on a submarginal row of black spots.

Two forms of this species occur. In one *P. comma dryas*, the hind wings above are suffused with black on the outer half, so that the submarginal row of fulvous spots is obscured, and on the lower side the wings are more yellowish than in the other form. The latter is the typical form of *P. comma comma.*

The larva feeds upon hop, elm, nettle, and false-nettle. It is often abundant in hop-yards, and the chrysalids are commonly known as hop-merchants, from a saying that the golden or silvery color of the metallic spots on the back of the chrysalis indicates whether the price of hops is to be high or low. This species is found in Canada and the northern part of the eastern half of the United States; its range extends south to North Carolina, Tennessee, Arkansas, and Oklahoma. It is double-brooded in the North, and at least three-brooded in the South.

The violet tip, *Polygōnia interrogatiōnis.* — This butterfly (Fig. 471, 8) is somewhat larger than the preceding species of *Polygonia* and differs in the form of the silvery mark, which consists of a dot and a crescent resembling a semicolon. It received its scientific name from the Greek note of interrogation, which is identical with our semicolon. On the upper side, the outer margins of the wings and the tails of the hind wings are tinged with violet, which fact suggested its common name.

This species is dimorphic; and the two forms differ so constantly and in such marked manner that they were described as distinct species. In *P. interrogationis interrogationis* the upper surface of the hind wings is not much darker than that of the fore wings, and there is a submarginal row of fulvous spots in the broad ferruginous brown border. In *P. interrogationis umbrōsa* the outer two-thirds of the upper surface of the hind wings is blackish, and the submarginal fulvous spots are obliterated, except sometimes faint traces near the costal margin.

This species is found in Canada and throughout the United States east of the Rocky Mountains.

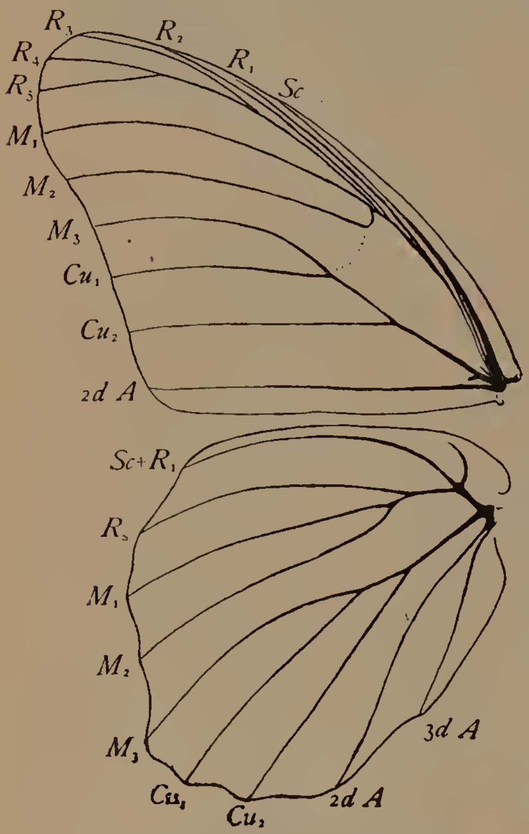


Fig. 473. — Wings of *Basilarchia astyanax.*

THE SOVEREIGNS

The members of this group differ from other Nymphalidæ in that the first three veins of the hind wings separate at the same point (Fig. 473); in the other nymphs the humeral vein arises beyond this point. The club of the antennæ is very long, and increases in size so gradually that it is difficult to determine where it begins. In its thickest parts it is hardly more than twice as broad as the stalk. The palpi are slender, and the wings are rounded.

The larvæ present a very grotesque appearance, being very irregular in form, and strongly mottled or spotted in color.

The following are our best-known species.

The banded purple, *Basilarchia arthemis.* — The upper surface of the wings is velvety chocolate-black, marked with a conspicuous white bow (Fig. 474).

This is a Canadian species which extends a short distance into the United States; the larva feeds on birch, willow, poplar, and many other plants.

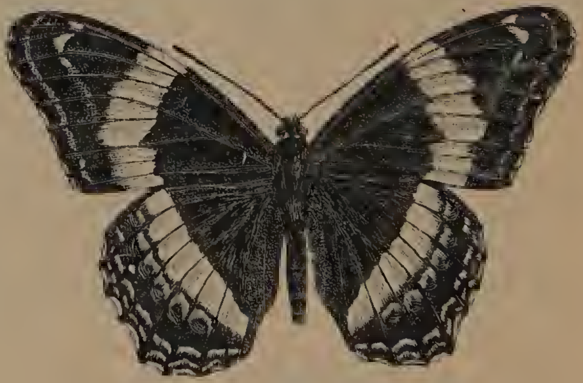


Fig. 474. — *Basilarchia arthemis.*

The red spotted purple, *Basilărchia astyănax.* — The upper surface of the wings is velvety indigo-black, tinged with blue or green. There are three rows of blue or green spots on the outer third of the hind wings; the spots of the inner row vary greatly in width in different individuals. On the lower surface there is a reddish-orange spot on the discal cell of the fore wings, and one on the discal vein; on the hind wings there are two orange spots similarly situated, a third at the base of cell R_1 and a row of seven spots just within a double row of submarginal blue or green spots.

This species occurs throughout nearly the whole of the Eastern United States south of the 43rd parallel of latitude. The larva feeds on many plants; among them are plum, apple, pear, and gooseberry.

The viceroy, *Basilărchia archĭppus.* — The wings vary in color from a dull yellow orange tinged slightly with brown to a dark cinnamon color; they are bordered with black, and all the veins are edged with the same color (Fig. 475). The fringe of the wings is spotted with white, and the black border on the outer margin contains a row of white spots.

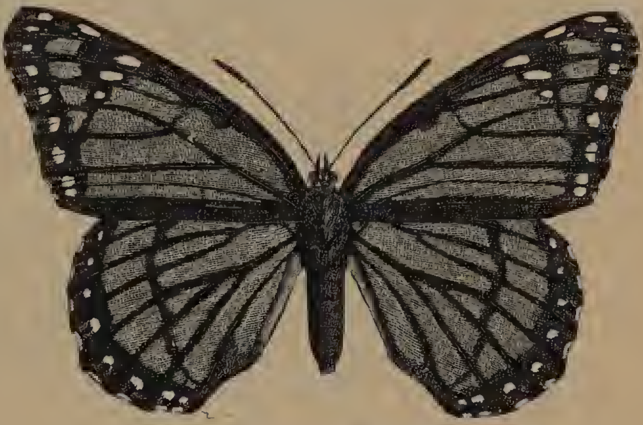


FIG 475. — *Basilarchia archippus.*

This species is remarkable for its resemblance to the monarch, *Danaus archippus* (Fig. 480). But aside from the structural characters separating the two subfamilies which these butterflies represent, the viceroy can be easily distinguished from the species it mimics by its smaller size, and by the presence of a transverse black band on the hind wings. As *Danaus archippus* has been termed the monarch, this species is aptly called the viceroy.

The larva (Fig. 476, *a*) when full-grown is about $1\frac{1}{5}$ inches in length. The body is humped and naked, with many tubercles. In color it is dark brownish-yellow or olive-green, with a pale buff or whitish saddle on the middle segment of the abdomen. The tubercles on the second thoracic segment are club-shaped and spiny.

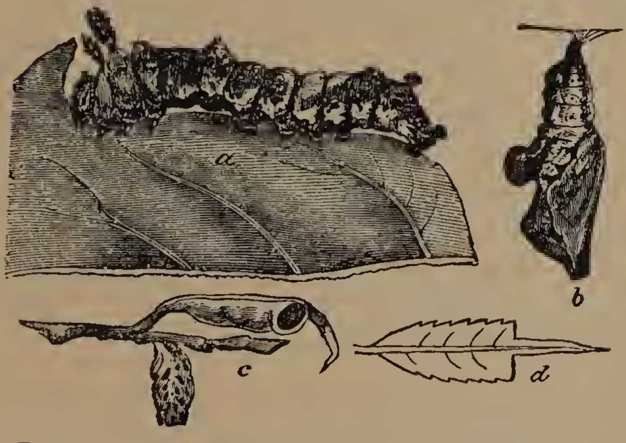


FIG. 476. — *Basilarchia archippus: a*, larva, *b*, pupa, *c*, nest; *d*, partly eaten leaf before rolled to form nest. (From Riley.)

The larva of the viceroy feeds upon willow, poplar, balm of gilead, aspen, and cottonwood. The species is two- or three-brooded and hibernates as a partially grown larva in a nest made of a rolled leaf (Fig. 476, *c*). This nest is lined with silk, and the leaf is fastened to the twig with silk so that it cannot fall during the winter. So far as is known all of the species of the sovereigns hibernate as larvæ in nests of this kind. It is worthy of note that only the autumn brood of caterpillars make these nests; so that the nest-building instinct appears only in alternate generations, or even less frequently when the species is more than two-brooded. *B. archippus* is found over nearly the whole of the United States as far west as the Sierra Nevada Mountains, and has been found sparingly even to the Pacific coast near our northern boundaries.

THE EMPERORS

This group is poorly represented in our fauna; our best-known species are the two following, which occur in the South.

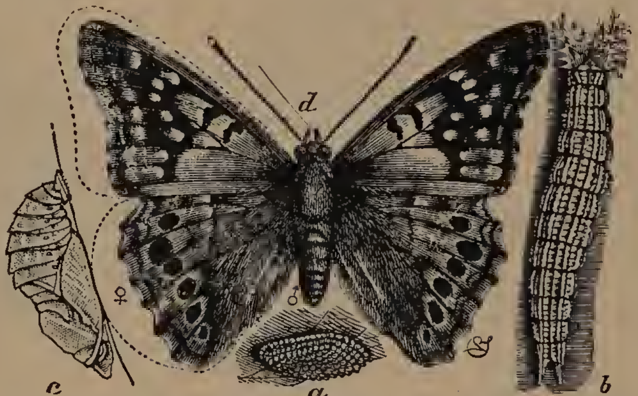


Fig. 477. — *Chlorippe clyton:* *a*, eggs; *b*, larva; *c*, pupa; *d*, upper surface of male butterfly; the dotted line at left indicates the contour of the wings of the female. (From Riley.)

The tawny emperor, *Chlorĭppe clȳton.* — In this species the apex of the front wings and the anal angle of the hind wings are considerably produced in the males, but more rounded in the females. The male is represented in Figure 477 and the dotted line at the left indicates the contour of the wings of the female. This excellent figure is from the sixth Missouri report by C. V. Riley, where a detailed account of the life-history of the species is given. The wings of this butterfly are more or less obscure tawny, marked with blackish-brown, and with pale spots. There is a submarginal row of six eye-like spots on the hind wings.

The species is dimorphic; the dimorphism affects both sexes and is independent, so far as is known, of season, as there is only one brood each year. It is the typical form *Chlorippe clyton clyton* that is figured here. The second form, *Chlorippe clyton prosĕrpina*, differs in having the hind wings darker and the submarginal row of eye-like spots wanting.

The larva (Fig. 477, *b*) feeds on hackberry.

THE ANÆAS

The butterflies of the genus *Anæa* are quite distinct from any of the preceding divisions of the Nymphalinæ, although they have been classed with the emperors. There are three species found in the United States, *A. pōrtia* from Florida, *A. morrisōnii* from Arizona, and the following one.

The goat-weed butterfly, *Anæa ăndria.* — The female of this species can be easily recognized by Figure 478. The male is smaller, with wings of a rich dark orange, margined with brown, and without the light-colored band characteristic of the female. This species is found in the Mississippi Valley from Illinois to Texas. The caterpillar has a large head, small neck and folds a leaf thus closely resembling the larva of a skipper.

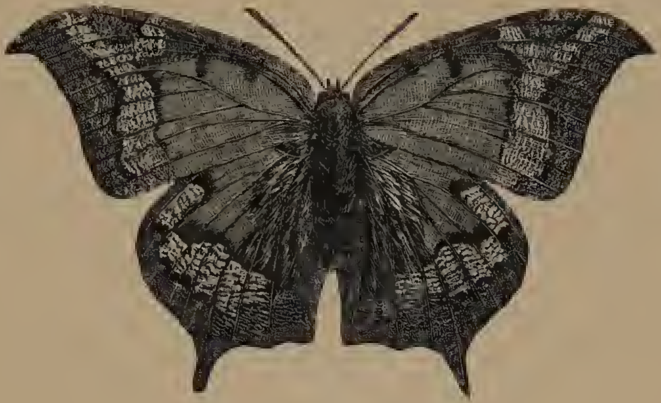


FIG. 478. — *Anæa andria.*

THE MEADOW-BROWNS

This subfamily includes chiefly brown butterflies whose markings consist almost entirely of eye-like spots. Some western species, however, are bright-colored. In our species some of the veins of the fore wings are greatly swollen at the base. This character is not quite distinctive; for in some species of the preceding groups of the Nymphalidæ that are found in southern Florida and in Texas near the Mexican border some of the veins of the fore wings are swollen at the base.

The larvæ are cylindrical, tapering more or less towards each end. The caudal segment is bifurcated, a character that distinguishes them from all other American butterfly larvæ excepting those of the emperors, *Chlorippe.*

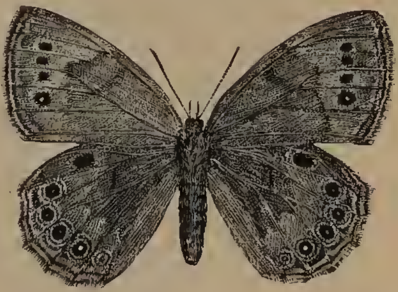


FIG. 479. — *Satyrodes canthus.*

The eyed brown, *Satyrōdes căntlius.* — The upper surface of the wings is soft mouse-brown on the basal half and paler beyond, considerably so in the female; each wing bears a row of four or five small black eye-like spots (Fig. 479). This species is found in Ontario, and throughout the eastern half of the United States in wet places. The larva feeds on swamp grasses; its head and caudal segment are each adorned with a pair of red cone-shaped tubercles.

The grayling, *Cercyŏnis ălope.* — This species is found from the Atlantic to the Pacific; it occurs under several forms, some of which have been described as distinct species. The most common forms found East of the Rocky Mountains are the first two described below and intergrades between these. The expanse of the wings is from 2 to 2½ inches. The larva feeds on grass.

(1) The blue-eyed grayling, *Cercyonis alope alope.* — The upper surface of the wings is dark brown; on the outer half of the fore wings there is a distinct yellow band, which extends from vein R_5 to the anal vein; in this band there are two dark spots with a white or bluish center. The hind wings usually bear a small spot in cell Cu_1, which is narrowly rimmed with yellow and has a minute white pupil. The lower surface of the hind wings is either with or without eye-like spots, usually with six of them.

(2) The dull-eyed grayling, *Cercyonis alope nĕphele.* — In this form the yellow band of the fore wings is either absent or represented by a faint pallid cloud. In other respects it closely resembles the blue-eyed grayling.

This is a northern form; the southern limits of its range overlap the northern limits of the range of the blue-eyed grayling as given above.

The White Mountain butterfly, *Œnēis semĭdea.* — The genus *Œneis* is composed of cold-loving arctic species whose natural habitat is the far North; but some members of this genus are found within the limits of the United States. Their presence here and their distribution are extremely interesting. The best-known of these forms is the White Mountain butterfly.

This butterfly is found only on the higher parts (above 5,000 feet) of the White Mountains in New Hampshire, and on the highest peaks of the Rocky Mountains of Colorado, above 12,000 feet.

These two widely separated colonies of this butterfly are believed to be the remnants of an arctic fauna which was forced southward during the Ice Age. At the close of this period, as the arctic animals followed the retreating ice northward, the tops of these mountains became colonized by the cold-loving forms. Here they found a congenial resting place, while the main body of their congeners, which occupied the intervening region, was driven northward by the increasing heat of the lower land. Here they remain, clinging to these islands of cold projecting above the fatal sea of warmth that fills the valleys below.

The White Mountain butterfly is a delicate-winged species. The upper surface of the wings is grayish-brown, without spots, except sometimes a minute one in cell M_1 of the fore wings; the fringe of the wings is brownish-white interrupted with blackish-brown at the ends of the veins. On the hind wings the marbling of the lower surface shows through somewhat. On the lower surface, the tip of the fore wings and the greater part of the hind wings are beautifully marbled with blackish-brown and grayish-white. The expanse of the wings is about 1⅘ inches.

THE HELICONIANS

This subfamily consists chiefly of tropical butterflies. They are of medium or rather large size, and are easily recognized by their narrow and elongated fore wings, which are usually more than twice as long as broad. Most of the species are striking in appearance, being black banded with yellow or crimson, and sometimes with blue. The discal cell of the hind wings is closed by a well-preserved vein. The following species is the only one found in our fauna that unquestionably belongs to this subfamily.

The zebra, *Helicōnius charitōnius.* — This is a black butterfly with its wings banded with lemon yellow. There are three bands on the fore wings; on the hind wings there is a broad band parallel with the front wings when they are spread, a submarginal row of about fifteen spots, and a row of dots on the outer margin near the anal angle. The wings expand from $2\frac{3}{5}$ to 4 inches. The larva feeds upon the passion-flower. This species is found in the hotter portions of the Gulf States.

The gulf fritillary, *Diōne vanĭllæ.* — In this species the front wings are about twice as long as broad, but the markings of the wings resemble those of a fritillary more than those of an heliconian. The wings are reddish fulvous above; the veins of the front wings are black on the outer two-thirds of the wing; the black expands into spots at the ends of veins M_3 to anal; there are two white spots in the discal cell and one at the apex of it, each of these spots is surrounded with black; cells M_3, Cu_1, and Cu_2 each contains a round black spot. The outer margin of the hind wings has a broad black border, which contains a fulvous spot in each cell. The wings expand from 2 to 3 inches.

The larva feeds on the passion-flower. In addition to the six rows of thorny spines, which characterize the caterpillars of many other fritillaries this one has on the head a pair of backward bending spines branched like the others.

This species occurs from New Jersey and Pennsylvania southward, also in Arizona and California.

THE MILKWEED BUTTERFLIES

These butterflies are of large size, with rounded and somewhat elongate wings, the apical portion of the fore wings being much produced. The discal cells of the wings are closed; the third anal vein of the fore wings is preserved; and the antennæ are apparently without scales. Only a very few species of this family occur in our fauna. The two following are the best-known.

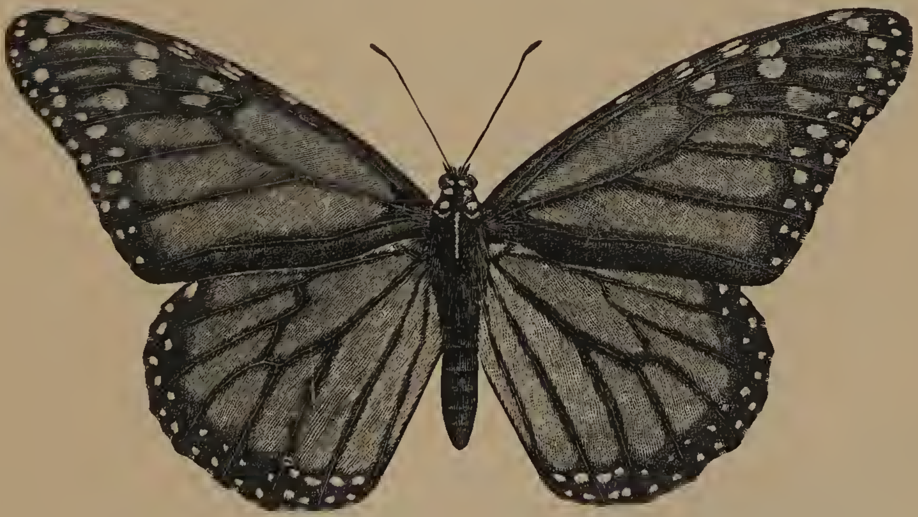


Fig. 480. — *Danaus archippus.*

The monarch, *Dānaus archĭppus.* — The upper surface of the wings is light ruddy brown, with the borders and veins black, and with two rows of white spots on the costal and outer borders as shown in Figure 480. The figure represents a female; in the male the veins of the wings are more narrowly margined with black, and there is a black pouch next to vein Cu_2 of the hind wings, containing scent-scales or androconia.

The larva feeds upon different species of milk-weed, *Asclepias*. When full-grown it is lemon or greenish-yellow, broadly banded with shining black. It is remarkable for bearing a pair of long fleshy filaments on the second thoracic segment, and a similar pair on the seventh abdominal segment (Fig. 481). The chrysalis is a beautiful object; it is bright green dotted with golden spots, and about 1 inch in length (Fig. 482).

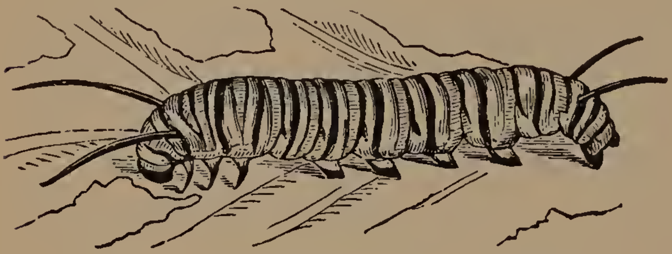


FIG. 481. — *Danaus archippus*, larva. (From Riley.)

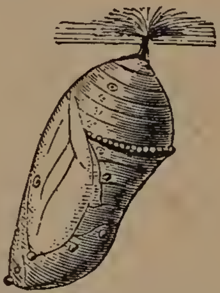


FIG. 482. — *Danaus archippus*, chrysalis. (From Riley.)

This species occurs throughout the greater part of the United States, and is distributed far beyond our borders. It is believed, however, that the species dies out each year in a large part of the Northern States, and that those butterflies which appear first in this region, in June or July, have flown hither from the South, where they hibernate in the adult state. In the extreme South they fly all winter. Great swarms, including many thousands of individuals of this species, are sometimes seen, late in the year; and these swarms appear to be migrating southward.

The queen, *Dānaus berenīce*. — This species is found in the Southern States. The upper surface of the wings is reddish chocolate-brown with the costal margin of the front wings and the outer margins of both pairs bordered with black. There are two partial rows of white dots near the costal and outer margins of the front wings; and there is a larger white spot in each of the cells R_5 to Cu. The male possesses a black pouch containing androconia next to vein Cu of the hind wings as in the preceding species. The wings expand from 2⅗ to 3 inches.

There is a well-marked variety, *Dānaus berenīce strigōsa*, in which on the upper surface of the hind wings the veins are narrowly edged with grayish-white.

The larva of this species feeds on milkweed. This larva bears three pairs of long, brown, whiplash filaments; these are on the second thoracic and the second and eighth abdominal segments.

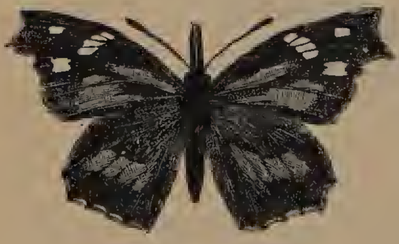


FIG. 483. — *Hypatus bachmanni.*

THE LONG-BEAKS

The long-beaks can be easily recognized by their excessively long, beak-like palpi, which are from one-fourth to one-half as long as the body and project straight forward (Fig. 483). The outer margin of the fore wings is deeply notched; the males have only four well-developed legs, while the females have six.

Only two species are listed from the United States, one from Texas and one from the East; and these may be merely varieties of one species.

The snout butterfly, *Hȳpatus bachmănni.* — The wings are blackish-brown above, marked with orange and white spots. This species occurs throughout the eastern United States, excepting the northern part of New England and the southern part of Florida. The larva feeds on hackberry, and in the West where hackberry does not occur, it feeds on wolfberry.

Family Lycænidæ

The Gossamer-winged Butterflies

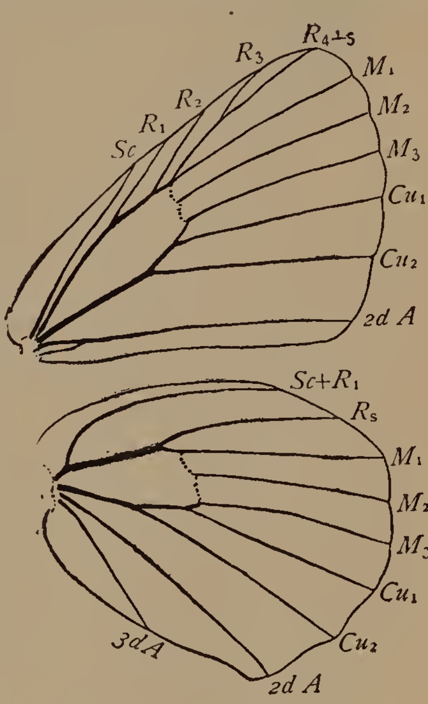


Fig. 484. — Wings of *Heodes thœ.*

The family Lycænidæ includes butterflies which are of small size and delicate structure. In size they resemble the smaller Hesperiidæ but they can be distinguished at a glance from the skippers, as they present an entirely different appearance. The body is slender, the wings delicate and often brightly colored, and the club of the antenna straight. The antennæ are nearly always ringed with white; each is situated very closely to the edge of an eye, often flattening it; they are not in pits; and a conspicuous rim of white scales encircles the eyes.

A characteristic of this family is that while in the female the front legs are like the other legs, in the male they are shorter, without tarsal claws, and with the tarsi more or less aborted. The venation is shown in Figure 484.

The caterpillars of the Lycænidæ present a very unusual form being more or less slug-like, reminding one of the larvæ of the Eucleidæ. The body is short and broad; the legs and prolegs are short and small, allowing the body to be closely pressed to the object upon which the insect is moving — in fact some of the species glide rather than creep; and the head is small, and can be retracted more or less within the prothorax. The body is armed with no conspicuous appendages; but some of the species are remarkable for having osmeteria which can be pushed out from the seventh and eighth abdominal segments, and through which honey-dew is excreted for the use of ants. Certain other species are remarkable in being carnivorous; one American species feeds exclusively upon plant-lice.

The chrysalids are short, broad, ovate, and without angulations. They are attached by the caudal extremity, and by a loop passing over the body near its middle. The ventral aspect of the body is straight and often closely pressed to the object to which the chrysalis is attached.

The family Lycænidæ is represented in our fauna by three well-marked groups of genera, which are hardly distinct enough to be ranked as subfamilies; these are known as the hair-streaks, the coppers, and the blues respectively. In addition to these there is a single species, the wanderer, the relationship of which is uncertain.

THE HAIR-STREAKS

The hair-streaks are usually dark brown, with delicate striped markings, which suggested their common name; but some species are brilliantly marked with metallic blue, green, or purple. The hind wings are commonly furnished with delicate tail-like prolongations (Fig. 485), and the eyes are hairy. The fore wings of the male often bear a small, dull, oval spot near the middle of the costal part of the wings, the discal stigma, which is filled with the peculiar scent-scales known as androconia. The males are also distinguished by having a tuft of hair-like scales, the beard, on the front; this is wanting or very thin in the females. More than sixty species occur in America north of Mexico; of these nearly twenty occur in the eastern half of the United States.

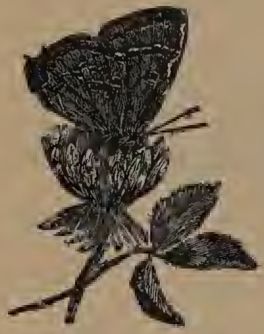


FIG. 485. — *Thecla calanus.*

The banded hair-streak, *Thĕcla călanus.* — In the northeastern United States the most common of the hair-streaks is this species (Fig. 485). The upper surface of the wings is dark brown or blackish-brown. The under surface is blackish slate-brown nearly as dark as the upper surface, and marked as shown in the figure.

The larva feeds on oak and hickory. Excepting the southern portion of the Gulf States, the species is found throughout our territory east of the Rocky Mountains, and in the southern part of Canada.

The olive hair-streak, *Mitoura dāmon.* — The upper surface of the wings is dark brown, with the disk more or less deeply suffused with brassy yellow in the male or tawny in the female; the hind wing has two tails, one much longer than the other, both black tipped with white. The lower surface of the hind wings is deep green; both fore and hind wings are marked with white bars bordered with brown. (Fig. 471, 6.)

Southern individuals have much longer tails than the one shown in the figure; and there is a variety, *patersōnia*, in which the upper surface of the wings is all dark brown.

The larva feeds on red cedar and smilax. This species occurs from Massachusetts to Florida and westward to Dakota and Texas.

The great purple hair-streak, *Ătlides halēsus.* — This is the largest of our eastern hair-streaks, the larger individuals expanding 2 inches. In the male the greater part of the upper surface of the wings is bright blue; the discal stigma, the outer fourth of the fore wings, the apex of the inner margin of the hind wings, and the tails are black. In the female the outer half of the wings is black.

This species occurs in the southern half of the United States and southward. It has been found as far north as Illinois. The larva is said to feed on oak.

The white-m hair-streak, *Thecla m-ălbum.* — This is a smaller species, expanding about 1½ inches. The upper surface of the disk of the wings is a rich, glossy dark blue, with green reflections; a broad outer border and costal margin are black. The hind wing has two tails, and a bright dark orange spot preceded by white at the anal angle. The under surface is brownish-gray, and on this surface both wings are crossed by a common, narrow white stripe which forms a large W or reversed M on the hind wings.

This species occurs in the southern half of the United States. The larva feeds on oak and on milk-vetch.

THE COPPERS

The coppers, as a rule, are easily distinguished from other gossamer-winged butterflies by their orange-red and brown colors, each with a coppery tinge, and conspicuous black markings. They are the stoutest of the Lycænidæ. Among the exceptions to the more common coloring of these insects are the following: In the male of *Heodes epixanthe*, a small species which frequents cranberry bogs, the wings have a purple tinge; and in *Heodes heteronea*, a species found from California to Colorado, the male is blue.

Eighteen species of the group are now listed in our fauna; the two following will serve as examples:

The American copper, *Heōdes hypophlœas.* — This is the most common of our coppers in the Northeastern States and in Canada. Its range extends also along the boundary between the United States and Canada to the Pacific Ocean, and southward into California; and in the east along the Alleghany Mountains south to Georgia. The fore wings are orange-red above, spotted with black, and with a blackish-brown outer border; the hind wings are coppery-brown, with a broad orange-red band on the outer margin; this band is indented by four black spots. The larva feeds on the common sorrel (*Rumex acetosella*).

The bronze copper, *Heodes thœ.* — This is larger than the preceding species, the wings expanding 1½ inches or more. In the male the wings are coppery-brown above, spotted with black, and with a broad orange-red band on the outer margin of the hind wings. The female differs in having the fore wings orange-red above, with prominent black spots.

This species occurs in the Middle and Western States from the Connecticut Valley to Nebraska. The larva feeds on curled dock (*Rumex crispus*).

THE BLUES

The blues can be distinguished from the other gossamer-winged butterflies by the slender form of the body, and the blue color of the upper surface of the wings of the males at least; in many species the upper surface of the wings of the female is much darker than that of the male. Thirty-eight North American species have been described; but most of these occur only in the far West. This is a rather difficult group to study owing to the fact that in several cases a single species exists under two or more distinct forms, and also that the two sexes of the same species may differ greatly. It often happens that two individuals of the same sex but of different species resemble each other more closely in the coloring of the upper surface than do the two sexes of either of the species.

The spring azure, *Lycæna argīolus.* — In this species the hind wings are without tails, the eyes are hairy, and the lower surface of the wings is pale ash-gray. This combination of characters will distinguish it from all other blues occurring in the eastern United States. But the species is not confined to this region, as it occurs in nearly all parts of the United States, in a large part of Canada, and most of the Old World.

This butterfly exhibits polymorphism to the greatest degree of any known species. In this country alone there are thirteen or more named forms. Some of these are geographical races; some are seasonal forms; and some are distinct forms that exist at the same time and place as the more typical form. In the Old World many other forms of this species have been described. Two forms are represented in Figure 471, 1 and 7.

The larva feeds on the buds and flowers of various plants, especially those of *Cornus*, *Cimicifuga*, and *Actinomeris*. They are frequently attended by ants for the sake of the honey-dew which they excrete from osmeteria which they push out from the seventh and eighth abdominal segments.

The tailed blue, *Evēres comȳntas.* — The butterflies of the genus *Everes* can be distinguished from our other blues by the presence of a small tail-like prolongation of the hind wing. This is borne at the end of vein Cu. Our common species (*E. comyntas*) is distributed over nearly all parts of North America. The male is dark purplish-violet above, bordered with brown; the female is dark brown, sometimes flecked with bluish scales. In the Eastern United States this is the only species of the genus.

The larva feeds upon clover and other leguminous plants.

THE GENUS, FENISECA

The wanderer, *Fenĭseca tarquĭnius.* — This is the only known member of the genus *Feniseca*. It does not seem to belong to either of the three groups of genera mentioned above. A distinctive feature of this genus is the fact that vein M_1 of the fore wings coalesces with a branch of radius for a considerable distance beyond the apex of the discal cell; in this respect it differs from all other members of the Lycænidæ found in our fauna.

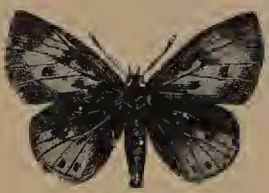


FIG. 486. — *Feniseca tarquinius.*

The upper surface of the wings of this butterfly (Fig. 486) is dark brown, with a large irregular, orange-yellow patch on the disk of the fore wing; and one of the same color next the anal angle of the hind wing.

This species is of unusual interest, as the larva is carnivorous in its habits. It feeds on plant-lice; and, so far as observed, it feeds only on the woolly aphids. It is found more often in colonies of the alder blight (*Schizoneura tessellata*) than in those of the allied species. It is found from Maine to northern Florida and westward to Kansas. It is a very local insect, being found only in the neighborhood of water where alder grows.

I do not know why the name the "wanderer" was applied to this butterfly, it may have been on account of its local appearance in widely separated places, or because in habits the larva deviates far from the more usual habits of caterpillars. The name is also appropriate as its nearest relatives are found in Africa and in Asia.

The chrysalis of *Feniseca* presents a remarkable appearance (Fig. 487); the anterior half when viewed from above bears a curious resemblance to a monkey's face; and it differs from all other lycænid pupæ in our fauna in having on each side a row of small rounded tubercles.

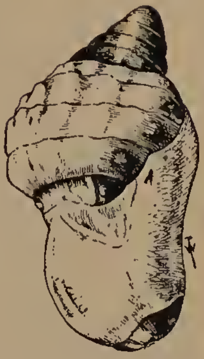


Fig. 487. — Chrysalis of *Feniseca*. Enlarged.

FAMILIES OF LEPIDOPTERA NOT DISCUSSED

The order Lepidoptera contains a large number of families the members of which are not commonly collected by the general student. The following list includes the families not discussed in this Manual but of which the student can find an account in "An Introduction to Entomology" by J. H. Comstock.

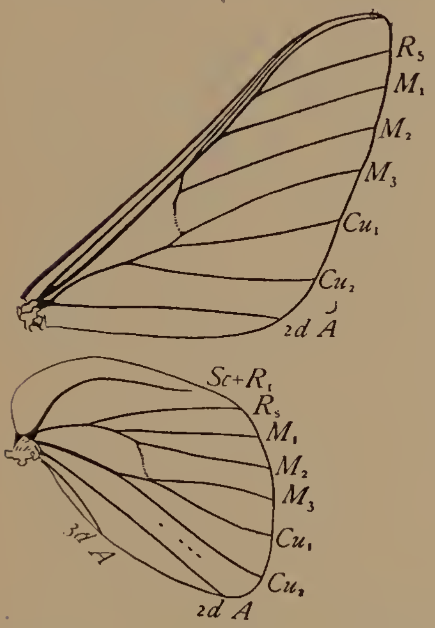


Fig. 432. — Wings of *Anisota virginiensis*. See pages 246 and 248.

Nepticulidæ
Dalceridæ
Epipyropidæ
Acrolophidæ
Tischeriidæ
Oinophilidæ
Elachistidæ
Heliozelidæ
Douglasiidæ
Ethmiidæ
Stenomidæ
Blastobasidæ
Cosmopterygidæ
Scythrididæ
Glyphipterygidæ
Heliodinidæ
Phaloniidæ
Carposinidæ
Orneodidæ
Thyrididæ
Hyblæidæ
Manidiidæ
Dioptidæ
Pericopidæ
Euchromiidæ
Eupterotidæ
Epiplemidæ
Thyatiridæ
Drepanidæ
Lacosomidæ
Riodinidæ

CHAPTER XXV

ORDER DIPTERA *

The Flies

The winged members of this order have only two wings; these are borne by the mesothorax. The second pair of wings is represented by a pair of knobbed, thread-like organs, the halteres; these are present in nearly all flies, even when the mesothoracic wings are wanting. The mouth-parts are formed for sucking. The metamorphosis is complete.

To the order Diptera belong all insects that are properly termed flies, and only these. The word fly forms a part of many compound names of insects of other orders, as butterfly, mayfly, and chalcis-fly; but when used alone, it is correctly applied only to dipterous insects. To some flies other common names have been applied as mosquito, gnat, and midge.

The presence of a single pair of wings and of a pair of halteres is sufficient to distinguish most members of this order from those of all other orders, except in the case of male coccids.

The wings of flies are thin, membranous, and usually either naked or clothed with microscopic hairs; but with mosquitoes the wings bear scales, and with the moth-like flies (Psychodidæ) and some others the clothing of hairs is very conspicuous. The hind wings are represented by a pair of knobbed organs, the *halteres;* these can be easily seen in a crane-fly (Fig. 488). They are present in nearly all flies, even when the front wings are wanting.

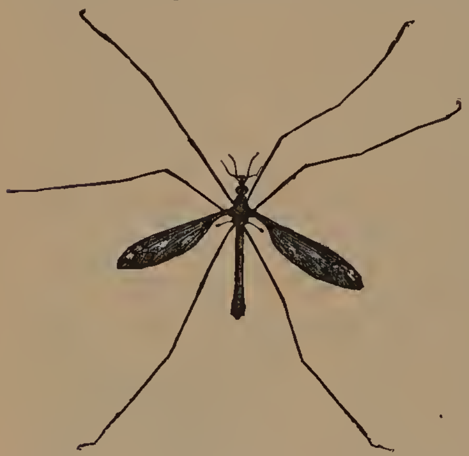


Fig. 488. — A crane-fly, showing wings and halteres.

The mouth-parts of flies are formed for sucking, and sometimes also for piercing. Their structure differs greatly in different families; and in some cases it is exceedingly difficult to determine the correspondence of the different parts. In the more typical forms the mouth-parts consist of six bristle-like or lance-like organs enclosed in a sheath, and a pair of jointed palpi.

According to the most generally accepted view the six bristles represent the upper lip (*labrum*), the tongue (*hypopharynx*), the two mandibles, and the two maxillæ, and the sheath enclosing these bristles is the lower lip (*labium*). The palpi which are not enclosed in the sheath are the maxillary palpi. At the tip of the lower lip there is, on each side, a lobe-like appendage; these are the labial palpi. The labial palpi of certain flies are quite large; in the housefly, for example, they are expanded into broad plates, which are fitted for a slight rasping function.

In their transformations flies pass through a complete metamorphosis. The larvæ are commonly called maggots. These are usually cylindrical and are footless; some possess a distinct head, others do not; and there are remarkable variations in the form of the respiratory organs, especially as to the number and position of the spiracles. The pupæ are usually either naked or enclosed in the last larval skin. A few are enclosed in cocoons. When the pupa state is passed within the last larval skin the body of the pupa separates from the larval skin more or less completely; but the larval skin is not broken till the adult fly is ready to emerge. In this case the larval skin, which serves as a cocoon, is termed a *puparium*. In some families the puparium retains the form of the larva; in others the body of the larva shortens, assuming a more or less barrel-shaped form (Fig. 553), before the change to a pupa takes place.

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* Dĭptera: *dis* (δις), two; *pteron* (πτερόν), a wing.

This is a large order, both in number of species and individuals. The species differ much in habits. Some are very annoying to man. Familiar examples are the mosquito, which attacks his person; the flesh-flies which infest his food; the bot-flies and gad-flies that torment his cattle; and the gall-gnats that destroy his crops. Other species are very beneficial. Many of the Syrphidæ, and Tachinidæ destroy certain noxious insects; and other species, while in the larval state, feed upon decaying animal and vegetable matter, thus acting as scavengers.

Although the habits of some of these creatures, which revel in all kinds of filth, are very disgusting, we cannot help admiring that arrangement by which a mass of filth, instead of being left to poison the atmosphere, is transformed into myriads of living beings, whose swift flight and delicate forms lend life and beauty to the landscape.

CLASSIFICATION OF THE DIPTERA

In the following table for determining the families of the Diptera, use is made chiefly of characters based on the form of the head, antennæ, and wings.

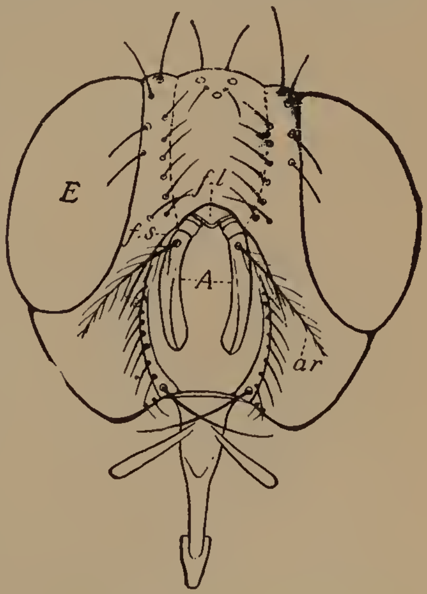

Fig. 489. — Head of a fly: *A*, antennæ; *ar*, arista; *E*, eye; *f.l.*, frontal lunule; *f.s.*, frontal suture.

The more important of the characters presented by the head are the presence or absence of the frontal lunule, and the presence or absence of the frontal suture when the lunule is present.

The *frontal lunule* is a small crescent-shaped piece immediately above the antennæ, which is characteristic of the second suborder, the Cyclorrhapha. In most of the members of this suborder there is a suture separating the lunule from that part of the head above it, the *frontal suture;* and frequently this suture extends down on each side to near the mouth (Fig. 489). But as the suture is wanting in several families of the Cyclorrhapha, it is often difficult to determine whether the lunule is present or not.

In those families that possess the frontal suture there exists a large bladder-like organ, the *ptilinum* which is pushed out through this suture when the adult is about to emerge from the puparium. In this way the head end of the puparium is forced off, making a large opening through which the adult escapes; afterwards the ptilinum is withdrawn into the head. If a specimen is captured soon after its emergence from the puparium, there may be seen instead of the frontal suture the bladder-like ptilinum projecting from the head, immediately above the antennæ.

The form of the antennæ is of prime importance in determining to what family a fly belongs. In the more generalized families the antenna consists of many segments, which, except the basal two, are similar in form (Fig. 490). Frequently such antennæ bear whorls of long hairs (Fig. 491). In the more specialized families there is a reduction in the number of segments of the antenna. This is brought about either by a more or less complete consolidation of the segments beyond the second into a single segment (Figs. 492 and 493), or by a dwindling of the terminal segments, so that they form merely a slender style (Fig. 494) or bristle (Fig. 495). Such a bristle is termed by many writers the *arista*. In most cases where a style or arista exists it is borne by the third segment, and this segment is then usually greatly enlarged. When the enlargement of this segment has taken place evenly the style or arista is terminal; but frequently one part of the third segment is expanded so that it projects beyond the insertion of the arista (Fig. 496); then the arista is said to be dorsal.

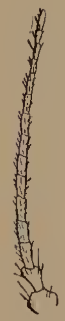

FIG. 490.

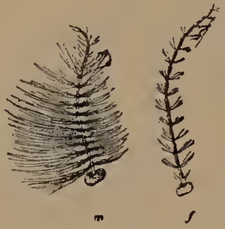

FIG. 491.

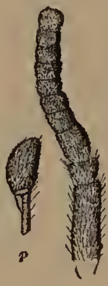

FIG. 492.

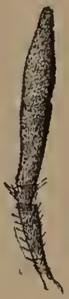

FIG. 493.

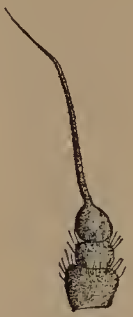

FIG. 494.

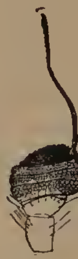

FIG. 495.

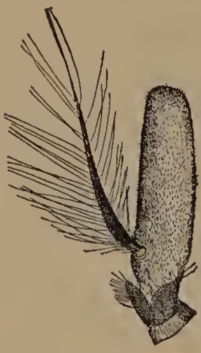

FIG. 496.

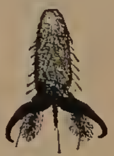

FIG. 497.

The legs vary greatly in length and in stoutness. The coxæ are usually long, and in most of the fungus-gnats (Mycetophilidæ) they are very long. When pulvilli are developed they are membranous pads, one beneath each tarsal claw. A third appendage, the *empodium*, often exists between the two pulvilli of each tarsus. The empodia may be bristle-like, or tapering (Fig. 497), or membranous, resembling the pulvilli in form (Fig. 498); in the last case they are described as *pulvilliform*.

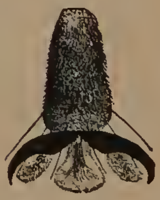

FIG. 498.

Variations in the form and venation of the wings afford characters that are much used in the classification of flies. In many families there is a notch in the inner margin of the wing near its base (Fig. 499, *a e*); this is the *axillary excision;* that part of the wing lying between the axillary excision and the base of the wing is the *pos-*

terior lobe (Fig. 499, *l*). In certain families there is a membrane beneath the base of the wing and above the halter or rudimentary hind wing; this is the *alula* or *alulet*. The alulæ are well developed in the common housefly. Each alula, in those species where the alulæ are well developed, consists of two lobes which fold over each other when the wings are closed. The alulæ are called the *tegulæ* by many writers on Diptera; but the term *tegula* was first used in insect anatomy for the cup-like scale which covers the base of the wing in certain insects, as most Hymenoptera, and should be restricted to that use. The terms alula and alulet are also often misapplied, being used to designate the posterior lobe of the wing.

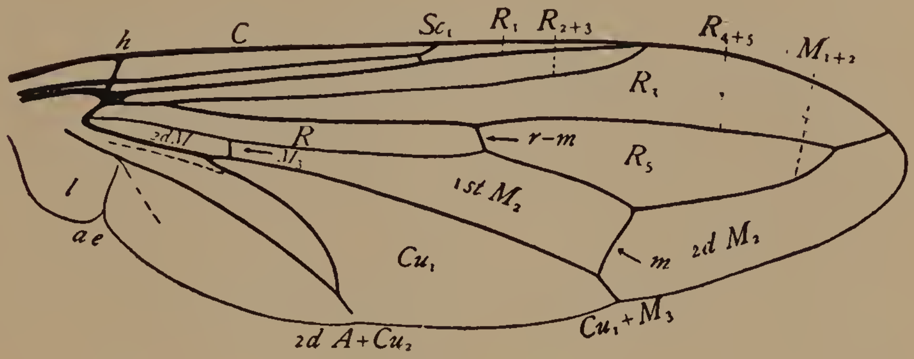

FIG. 499. — Wing of *Conops*.

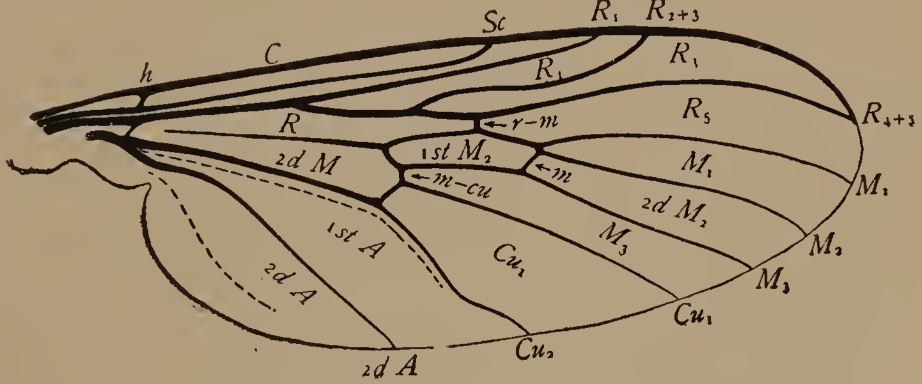

FIG. 500. — Wing of *Anisopus*.

The plan of the venation of the wings can be easily learned by a study of the wing of *Anisopus* (Fig. 500), which is very generalized in structure, except that vein R is only three-branched, which in certain still more generalized forms is five-branched (e.g., the primite wing of *Psychoda*, Fig. 506). In the figures of wings in this chapter both the veins and the cells are lettered. The letters outside of the margin of the wing refer to the veins; those within, to the cells, except when otherwise indicated by a dotted line or by an arrow. It should be remembered that each cell bears the same letter as the vein that forms its front margin when the wings are spread. When a cell is divided by a cross-vein the two parts are numbered 1st and 2d. Thus in *Anisopus*, cell M_2 is divided, and the parts are designated as the 1st cell M_2 and the 2d cell M_2 (Fig. 500, 1st M_2, 2d M_2). A cross-vein is marked *cv*.

The Costa extends along the costal margin of the wing; it usually ends somewhere near the apex of the wing; in *Anisopus* it ends at the tip of vein R_{4+5} (Fig. 500). In some families it extends entirely around the wing; it is then called the *ambient vein*. Vein Sc is simple. Vein R is typically five-branched; but the number of branches is usually reduced to four or to three. Vein M is three-branched in the more generalized forms. Vein Cu is two-branched. The first anal vein is usually merely a concave fold just behind vein Cu and parallel with that vein; it is represented in most of the figures of wings by a dotted line. The second anal vein is usually present; and sometimes the third anal vein also exists.

One of the most marked features in the specialization of the wings of Diptera is a tendency of the veins to coalesce from the margin of the wing towards the base. This is illustrated by the wing of *Conops* (Fig. 499). In this genus veins R_{4+5} and M_{1+2} coalesce at the margin of the wing; veins M_3 and Cu_1 coalesce for nearly their entire length. The result of this coalescence is to cause the free part of vein M_3 to appear like a cross-vein between cells M and the 1st cell M_2. Veins Cu_2 and 2d A also coalesce at the margin of the wing.

In a few genera of flies certain longitudinal veins are bent so as to form a sharp angle, and from this angle a spur is developed. Thus in the primitive crane-flies there is a sharp angle near the base of vein R_{2+5} which bears a spur; in *Mydas* a similar spur is formed on vein R_4 (Fig. 549); and in *Pantarbes* this spur on vein R_4 is prolonged so as to form a complete cross-vein dividing cell R_3 into two parts.

TABLE OF FAMILIES OF DIPTERA

A. Flies in which the abdomen is distinctly segmented, and the two legs of each thoracic segment are not widely separated. Habits various, but the adults do not live parasitically upon either birds or mammals.

B. Antennæ consisting of at least six distinct segments, the palpi in most cases of four or five segments (Nemocera).

C. Small moth-like flies, with the body and wings densely clothed with hair and scales. Wing with from nine to eleven longitudinal veins but with no cross-veins except sometimes near the base of the wing (Fig. 506). p. 295. .... Psychodidæ

CC. Flies that do not resemble small moths in appearance.

D. Mesonotum with a more or less distinct V-shaped suture (including Tanyderinæ, Ptychopterinæ and Pipulinæ). p. 293 .... Tipulidæ

DD. Mesonotum without a distinct V-shaped suture.

E. Media three-branched; ocelli present. p. 295. (In part) Anisopidæ

EE. Media simple, two-branched or wanting; cell M_2 not divided by a cross-vein.

F. Wing with network of fine lines. p. 304 .... Blepharoceridæ

FF. Wing without network of fine lines.

G. Margin of wings and wing-veins fringed with scales or scale-like hairs. (Fig. 512). p. 297 .... Culicidæ

GG. Wing veins with or without hairs but without fringe of scales.

H. Anal vein entirely wanting; vein M wanting or represented by a single unbranched fold. p. 301 .... Cecidomyidæ

HH. Anal vein usually present or represented by folds; vein M present or represented at least by a fold which is usually branched.

I. Ocelli present.

J. Antennæ shorter than the thorax; coxæ not usually long; cross-vein m-cu absent or present. p. 302 ...... Bibionidæ

JJ. Antennæ usually longer than the thorax and in many cases with much elongated coxæ.

K. With tibial spurs. p. 300.................Mycetophilidæ

KK. Without tibial spurs. p. 301..............Cecidomyidæ

II. Ocelli absent.

J. Antennæ short, segments wider than long; wings very broad. p. 303....................................Simuliidæ

JJ. Antennæ either with narrow segments or bushy with dense coat of hairs; wings narrow or moderately broad.

K. Media forked and cross-vein m-cu present. p. 295. ....Dixidæ

KK. Media not forked when m-cu cross-vein is present. (Inclusive of Thaumalea) p. 296..........Chironomidæ

BB. Antennæ consisting of not more than four segments, in some cases the last segment is again divided into several closely fused subsegments; palpi with not more than two segments; if the antennæ have numerous segments in exceptional cases, the empodium is developed pulvilliform (Fig. 498).

C. Empodium developed pulvilliform, that is, three rounded pads under the tarsal claws.

D. Third antennal segment consisting of several subsegments or antennæ consisting of more than three segments.

E. Branches of the radius crowded together near the costal margin in most cases (Fig. 536), tibiæ without spurs, costal vein discontinued at or before the apex of the wing. p. 307..................Stratiomyidæ

EE. Venation not of this type.

F. Alulets large; venation as in figure 532................Tabanidæ

FF. Alulets small or vestigial. Coenomyidæ, Xylomyidæ, and Xylophagidæ.

DD. Third antennal segment simple.

E. Alulets very large; head very small. p. 308....(Cyrtidæ) Acroceridæ

EE. Alulets small.

F. Costa extends around the apex of the wing. p. 307....Rhagionidæ

FF. Costa ends at the apex of the wing; venation intricate. ....*Nemestrinidæ*

CC. Empodium absent or in the form of a thread, that is, only two pads under the tarsal claws.

D. Antennæ consisting apparently of a single globular segment with arista; anterior veins of the wing stout, posterior veins weak. (Fig. 554). p. 313. ....Phoridæ

DD. Antennæ with but few exceptions with three easily distinguished segments.

E. Cells M and 1st M_2 not separated (Fig. 550).

F. Frontal suture absent; vein R with a knot-shaped swelling near the forking of the radial sector; the r-m cross-vein near this swelling when present; flies in most cases metallic in coloring. p. 310. ....Dolichopodidæ

FF. Frontal suture present; vein R with or without this swelling; the cross vein more remote from the base of the wing in most cases. Acalyptratæ such as some Drosophilidæ, p. 318, Agromyzidæ, p. 318, Ephydridæ, p. 317, Chloropidæ, p. 317, Borboridæ.

EE. Cells M (or 2d M) and 1st M_2 separate.

F. Radial sector three branched.

G. Vertex of the head distinctly hollowed out between the eyes; eyes never contiguous. Large species in most cases.

H. Proboscis with fleshy labella at tip; venation complicated (Fig. 549). p. 310....................................Mydaidæ

HH. Proboscis horny and rigid, without labella at tip. p. 309. ....Asilidæ

GG. Vertex not hollowed out between the eyes.

H. Cell M_3 present.

I. Vein R_5 ending before the apex of the wing........*Apioceridæ*

II. Vein R_5 not ending before the apex of the wing. p. 309. ....Therevidæ

H. Cell M_3 obliterated by the coalescence of veins M_3 and Cu_1.

I. Third segment of the antennæ without a style or an arista; vein M_1 ending at or before the tip of the wing. p. 309. ....Scenopinidæ

II. Third segment usually with style or arista; M_1 ending beyond the apex of the wing.

J. First branch of the cubitus extending free to the margin of the wing or coalesced with the vein 2d A for a short distance at the margin of the wing. p. 308........BOMBYLIDÆ

JJ. First branch of the cubitus joining 2d A far from the margin of the wing, often extending to the base of the wing. p. 311. ....EMPIDIDÆ

FF. Radial sector with not more than two branches.

G. Wings lanceolate (Fig. 552). p. 312................LONCHOPTERIDÆ

GG. Wings not of this type.

H. Vein Cu_2 not coalesced with 2nd A to such an extent as to cause the free part to appear like a cross-vein.

I. Antennæ with terminal arista, hind tarsi often broad and flat. (Fig. 495)......................................*Platypezidæ*

II. Antennæ with dorsal arista; or in some cases, a terminal style.

J. Head extremely large; entire surface nearly occupied by eyes. (Fig. 555). p. 313..........................PIPUNCULIDÆ

JJ. Head not of the type represented by figure 555.

K. Wing with a vein-like thickening, the spurious vein, between veins R and M; if wanting then front convex beneath antennæ (Fig. 556). p. 314.........SYRPHIDÆ

KK. Wing without spurious vein; front with grooves or a depression beneath the antennæ...............*Conopidæ*

HH. Vein Cu_2 appearing as a cross-vein or curved back toward the base of the wing (Figs. 550, 551).

I. Frontal suture absent; antennæ in most cases with a terminal style or arista. p. 311............................EMPIDIDÆ

II. Frontal suture present; antennæ with dorsal arista.

J. Alulæ or calypteres small or rudimentary; subcostal vein often indistinct or vestigial but often well preserved; vein R_1 rather short; thorax without complete transverse suture; abdominal spiracles in most cases in the conjunctiva. Acalyptratæ including AGROMYZIDÆ, p. 318, PIOPHILIDÆ, p. 316, DIOPSIDÆ, PSILIDÆ, p. 317, CHLOROPIDÆ, p. 317, ORTALIDÆ, p. 315, TRYPETIDÆ, p. 315, SAPROMYZIDÆ, etc.

JJ. At least the lower lobe of the calypteres or alulæ well developed; subcostal vein distinct for its whole course; transverse suture complete; abdominal spiracles in most cases in the lower margin of the tergites.

K. Proboscis much reduced or vestigial, not functional; mouth-opening small (bot-flies).

L. Cell R_5 wide open in the margin (horse bots), p. 319. ..................................GASTEROPHILIDÆ

LL. Cell R_5 nearly closed in the wing margin. p. 320. ....ŒSTRIDÆ

KK. Mouth-opening normal; mouth-parts functional.

L. Hypopleura (sclerite below the posterior spiracle and above hind coxæ) bare or with only some fine hairs.

M. Cell R_5 very slightly or not at all narrowed in the wing margin.

N. Alulets rather small, lower one not projecting noticeably beyond the upper; under surface of the scutellum without short, fine hairs; anal vein not suddenly flexed up toward the end. (Scatophagidæ). p. 318...........................CORDYLURIDÆ

NN. Alulets larger, the lower one projecting beyond the upper, or if small, either there are short hairs on the lower surface of the scutellum or the second anal vein is short and suddenly flexed up toward the end. p. 319...................ANTHOMYIDÆ

MM. Cell R_5 much narrowed in the wing-margin; arista plumose in most cases. p. 323........MUSCIDÆ

LL. Hypopleura with one or more vertical series of strong setæ.

M. Postscutellum very distinct, i.e., metanotum with a double convexity, (including Dexiinæ, Phasiinæ, and Megaprosopinæ). p. 323. . . . . TACHINIDÆ

MM. Postscutellum not distinct, metanotum with single convexity.

N. Notopleural setæ* (i.e., those just above the dorso-pleural suture in front of the base of the wing) two in number; hind coxæ bare behind, above base of hind femur; in most cases metallic greenish or bluish species. p. 321 . . . . CALLIPHORIDÆ

NN. Notopleural setæ three or four in number, if with but two, then arista either pubescent or bare; species in most cases grayish with a more or less tessellated abdomen. p. 322. . . . . SARCOPHAGIDÆ

AA. Parasitic flies in which the abdomen is indistinctly segmented (except in Braula) and the two legs of each thoracic segment are widely separated by the broad sternum. Parasitic upon bees, Braulidæ; upon bats, Streblidæ and Nycteribiidæ; upon other mammals and birds, Hippoboscidæ. p. 324. . . . . *Pupipara*

Suborder ORTHORRHAPHA †

The Straight-seamed Flies

This suborder includes those flies in which the pupa escapes from the larval skin through a T-shaped opening, which is formed by a lengthwise split on the back near the head and a crosswise split at the front end of this (Fig. 501), or rarely through a crosswise split between the seventh and eighth abdominal segments. The adults do not have a frontal lunule.

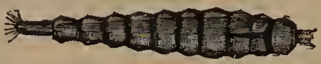

FIG. 501.

The families included in this suborder are commonly grouped in two series: the Nemocera and the Brachycera.

SERIES I. STRAIGHT-SEAMED FLIES WITH LONG ANTENNÆ

(*Nemocera* ‡)

Family TIPULIDÆ

The Typical Crane-flies

The crane-flies are mosquito-like in form; but they are usually very much larger than mosquitoes. The body is long and slender, the wings narrow, and the legs very long (Fig. 502). This family includes the larger members of the Nemocera but it also includes some species that are not larger than certain mosquitoes. The most distinctive feature of crane-flies is the presence of a transverse V-shaped suture on the dorsal side of the mesothorax (Fig. 503).

Crane-flies are seen most often in damp localities, especially where there is a rank growth of vegetation; but sometimes they occur in great numbers flying over meadows and pastures. In most cases their power of flight does not seem to be well developed for they fly slowly, and only a short distance at a time. Some species, however, sustain themselves in the air for long periods. This is especially true of some of the smaller species, which often collect in swarms at twilight, forming a small cloud, and dancing up and down like some of the midges. Their ability to walk is also poor; for they use their long legs awkwardly, as if they were in the way. This has suggested the rhyme: —

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* See "An Introduction to Entomology" by J. H. Comstock, p. 784.

† Orthŏrrhapha; *orthos* (ὀρός), straight; *rhaphe* (ῥαφή), a seam.

‡ Nemŏcera: *nema* (νῆμα), thread; (κέρας), horn.

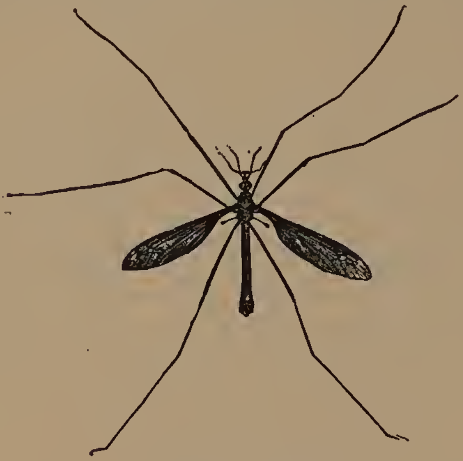

FIG. 502. — A crane-fly.

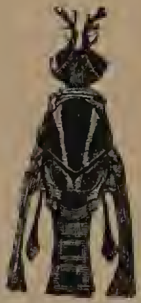

FIG. 503. — Thorax of a crane-fly showing the V-shaped suture.

"My six long legs, all here and there,
Oppress my bosom with despair."

The larvæ of crane-flies vary greatly in habits both as to the situations in which they live and as to the nature of their food. Some are aquatic; some live in or beneath damp cushions of moss. Many live in mud or sand along the margins of streams, in swamps, or in shaded woods, while others are strictly terrestrial, burrowing in the soil of meadows and pastures.

The larvæ of most species are scavengers feeding on decaying vegetable matter, but some feed on living vegetable tissue, and still others are carnivorous.

The Tipulidæ is a large family; nearly 3,000 species are known and about 500 species have been described from North America alone.

The larvæ of some species of crane-flies, most of which belong to the genus *Tipula*, often do considerable damage in meadows, pastures, and grain fields by devouring the roots of the plants. The full-grown larvæ are about one inch long and of a dirty-grayish color. As the body-wall is of a tough leathery texture these larvæ are commonly known as leatherjackets. Serious outbreaks of these pests have occurred at various times in Ohio, Indiana, Illinois, and California. In the case of the species infesting ranges, pastures, and grain and alfalfa fields in California it was found that the larvæ usually come out upon the surface of the ground during the night and could be destroyed by the use of poisoned-bran bait, made by mixing one pound of Paris green, twenty-five pounds of bran, and sufficient water to make a flaky mash. The bait is applied with a broadcast grain seeder.

There are three other families of closely related crane-flies, namely: the primitive crane-flies, *Tanyderidæ*, which are of interest because they are the most generalized of living crane-flies; the phantom crane-flies, *Ptychopteridæ*, of which one species, *Bittacomŏrpha clăvipes*, is the most common and interesting. Its legs, which are banded with black and white are held outspread as it flies and make it a very conspicuous object as it drifts phantom-like through the air; and the false crane-flies *Anisŏpidæ*, some of which are mosquito-like with spotted wings and often enter houses where they are found on window panes. Others of the genus *Trichŏcera*, appear in swarms in autumn and early spring and sometimes on warm sunny days in winter.

Family Dixidæ

The Dixa-midges

These midges closely resemble mosquitoes in size and form; but the wing-veins do not bear scales. The family includes only a single genus, *Dixa*.

The adult midges occur in the vicinity of streams and in swampy places.

The larvæ are aquatic, living in ponds or slowly running water; they resemble somewhat those of *Anopheles* but the body is almost always bent so that the head and tail come close together. They progress by alternate thrusts of the two ends of the body, the bent portion traveling foremost (Fig. 504).

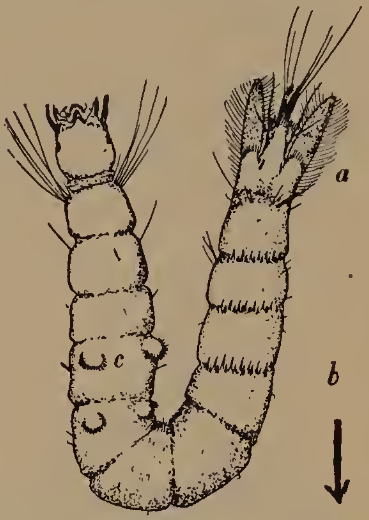

FIG. 504. — Larva of *Dixa*. (After Needham and Lloyd.)

Family Psychodidæ

The Moth-like Flies

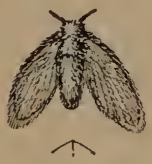

FIG. 505. — A moth-like fly.

There may be found frequently upon windows and on the lower surface of the foliage of trees small flies which have the body and wings densely clothed with hair and which resemble tiny moths in appearance. The wings are broad, and when at rest slope at the sides in a roof-like manner or are held horizontally in such a way as to give the insect a triangular outline (Fig. 505). The venation is peculiar; cross-veins are almost wanting (Fig. 506).

The moth-like appearance of these insects is sufficient to distinguish them from all other flies.

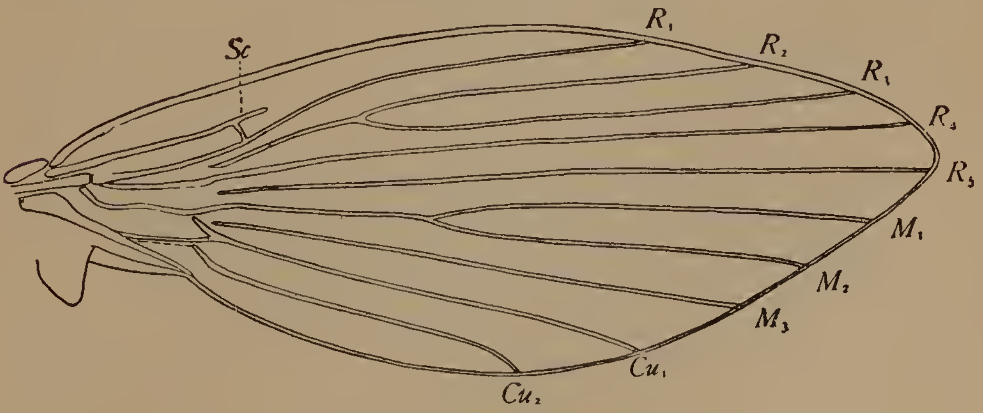

FIG. 506. — Wing of a moth-like fly.

The antennæ are long and slender, and are clothed with whorls of hairs (Fig. 507).

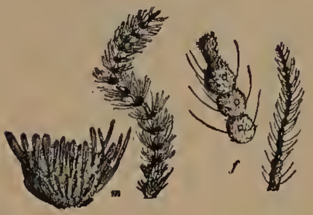

FIG. 507. — Antennæ of *Psychoda*. *m*, antenna of male and the second segment of the same more enlarged; *f*, antenna of female and the tip enlarged.

The moth-like flies are often very minute and rarely exceed $\frac{1}{6}$ of an inch in length. Most of the species, so far as is known, feed on nectar or other fluid matter other than blood; but the species of the genus *Phlebŏtomus* are blood-suckers, feeding upon the blood of various reptiles, amphibians and mammals, including man; and it has been found that some exotic species transmit certain diseases of man, as the European pappatici fever, or three day fever, and the Peruvian verruga. One or two species of the genus, *Phlebotomus*, have been found in the United States.

The larvæ of members of this family are found in various situations; in decaying vegetable matter, in sewage, in cow dung, in exuding sap on tree-trunks, and in streams.

Family CHIRONOMIDÆ

The Midges

The members of this family are more or less mosquito-like in form, but are usually more delicate than mosquitoes. The abdomen is usually long and slender; the wings narrow; the legs long and delicate; and the antennæ, especially in the males, strongly plumose (Fig. 508). In fact many of these insects are commonly mistaken for mosquitoes; but only a few of them can bite, the greater number being harmless.

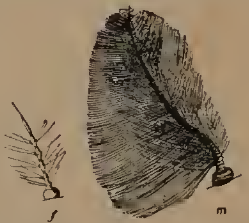

FIG. 508. — Antennæ of *Chironomus*. *f*, female; *m*, male.

The midges are most easily distinguished from mosquitoes by the structure of the wings (Fig. 509). These are furnished with fewer and usually less distinct veins; and the veins, although sometimes hairy, are not fringed with scale-like hairs.

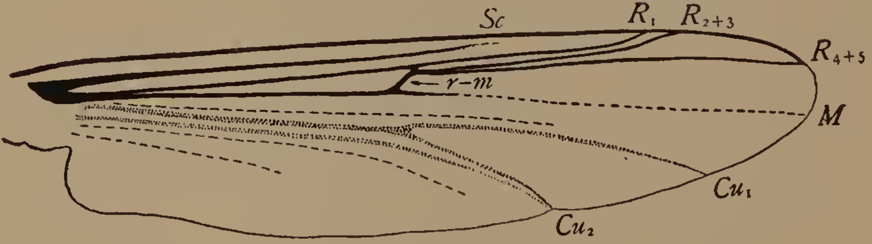

FIG. 509. — Wing of *Chironomus*.

The name midge has been used in an indefinite way, some writers applying it to any minute fly. It is much better, however, to restrict it to members of this family except where it has become firmly established as a part of a specific name.

Midges often appear in large swarms, dancing in the air, especially towards the close of day. Professor Williston states that, over meadows in the Rocky Mountains, he has seen them rise at nightfall in most incredible numbers, producing a buzzing or humming noise like that of a distant waterfall.

Most larvæ of midges are aquatic; but some live either in manure, in decaying vegetable matter, under bark, or in the ground. Some of the pupæ are free and active, others are quiescent. The larvæ and pupæ of the aquatic species are of much importance as fish-food.

Many of the aquatic larvæ live in tubes which they build of bits of dead leaves and particles of sand fastened together with viscid threads. These tubes are frequently seen upon the surface of dead leaves, stones, and sticks; and they are often made in the mud of the bottom of a pool, in which case they open at the surface of the mud. Many of the species are blood-red in color, and hence are frequently known as *blood-worms*.

The aquatic larvæ feed on algæ, decaying vegetable matter, diatoms, and small crustacea; the terrestrial species, on manure or decaying vegetable matter. There are a few cases reported of the larvæ infesting the roots of plants in greenhouses and mining in the leaves of plants.

To the genus *Culicoides* belong the small midges commonly known as sandflies or punkies. Certain minute species are sometimes very abundant, and extremely annoying on account of their bites. They are exceedingly troublesome in the Adirondack Mountains, in the White Mountains, and along mountain streams generally; they are also abundant in some places at the seashore. These tiny midges are sometimes called "no-see-um," an Indian name for them (Fig. 510).

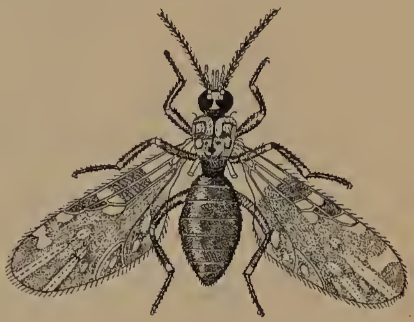

Fig. 510. — A punkie, *Culicoides guttipennis*.

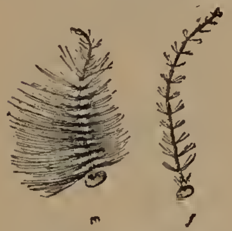

Fig. 511. — Antennæ of mosquitoes. *m*, male; *f*, female.

Family CULICIDÆ

The Mosquitoes

The mosquitoes are small flies, with the abdomen long and slender, the wings narrow, the antennæ plumose in the males, (Fig. 511), and usually with a long, slender, but firm proboscis. The most distinctive feature of mosquitoes is the fringe of scale-like setæ on the margin of the wings and also in most cases on each of the wing-veins (Fig. 512).

The mouth-parts of most mosquitoes are constructed for piercing and

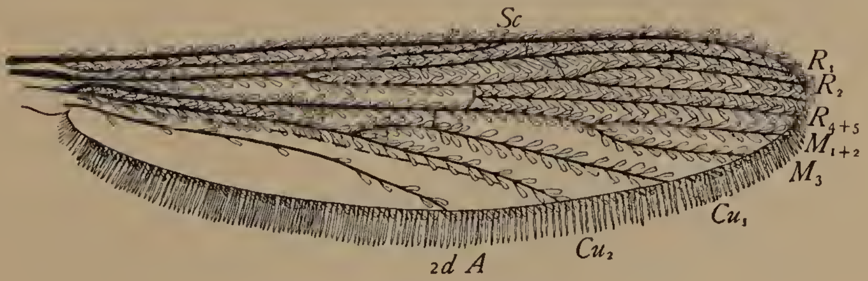

Fig. 512. — Wing of a mosquito.

sucking. They consist of six bristles or stylets enclosed in a sheath formed by the labium. In those members of the subfamily, *Corethrinæ*, the mouth-parts are short and not adapted to sucking.

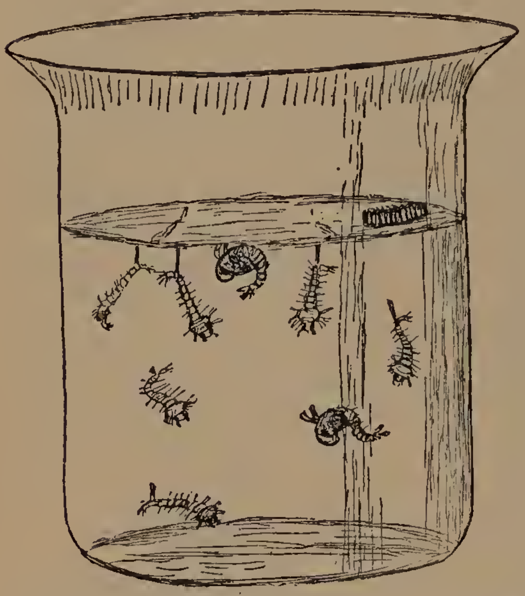

FIG. 513. — A glass of water containing eggs, larvæ, and pupæ of mosquitoes.

The different species of mosquitoes differ greatly in their manner of oviposition. Those most often observed about water-barrels, *Culex*, lay their long, slender eggs side by side in a boat-shaped mass, on the surface of the water (Fig. 513); species of *Anopheles* deposit their eggs separately upon the surface of the water; and many *Aëdes* lay their eggs on the ground after the pools in which they were developed have dried out. In this case the eggs remain unhatched until later rains or melting snows refill the pools. The eggs of some mosquitoes hatch very soon after they are laid; but with the majority of species the winter is passed in the egg state.

The larvæ of mosquitoes are all aquatic. They are well known and are commonly called "wigglers," a name suggested by their wriggling motion as they swim through the water. They vary in details of structure but the larva of *Culex* will serve to illustrate the general form of the body (Fig. 514, *a*). The head and thorax are large and the abdomen is slender. The next to the last abdominal segment, the eighth, bears a breathing-tube; and when the larva is at rest it hangs head downward in the water, with the opening of this tube at the surface (Fig. 513). At the end of this tube there is a rosette of plate-like lobes (Fig. 515, *a*) which resting on the surface film, keeps the larva in position.

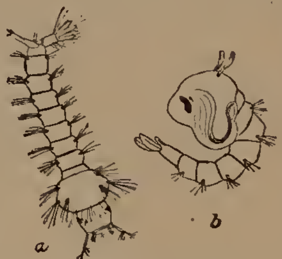

FIG. 514. — Mosquitoes. *a*, larva; *b*, pupa.

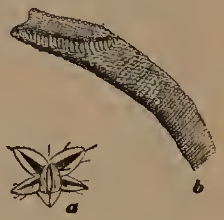

FIG. 515. — *a*, end of breathing-tube of larva; *b*, breathing tube of pupa.

The food of most mosquito larvæ consists of organic matter which they find in the water in which they live. Some larvæ are predacious on small aquatic animals.

The pupæ of mosquitoes like the larvæ are aquatic, but they differ greatly in form from the larvæ (Fig. 514, *b*). The head and thorax are greatly enlarged and are not distinctly separated, while the abdomen is slender and flexible. With the change to the pupa state a remarkable change takes place in the respiratory system. There are now two breathing tubes, and these are borne on the thorax.

Only female mosquitoes suck blood and many of these attack birds and mammals rather than man. Some species are said not to suck blood at all. Male mosquitoes feed on nectar, the juices of ripe fruits and other sweet substances.

The small group of mosquitoes of the subfamily, *Corethrinæ*, have short probosces unfitted for sucking blood. The larvæ of these forms are predacious and live on infusoria, small crustaceans and small larvæ of other mosquitoes. All of our common mosquitoes belong to the subfamily, *Culicinæ*, the more important ones to the genera, *Culex*, *Anopheles* and *Aëdes*.

Cūlex. — To this genus belong our common house mosquitoes that have unspotted wings and short palpi in the females. These are very annoying pests; but although many of the species of this genus transmit blood diseases of birds and animals they do not play an important rôle in human diseases except one species which conveys the organism causing elephantiasis.

Aëdes. — This is a very large genus of world-wide distribution. The species vary greatly in habits; but with most of them the larvæ develop from over-wintering eggs in early spring pools. Some species, however, breed in water-barrels, and other artificial containers; one of these is the carrier of yellow fever.

The yellow-fever mosquito, *Aëdes ægȳpti*, is distributed throughout all tropical regions of the world and is often carried by commerce into temperate regions. But as it is destroyed by frost it can not become established when frosts occur. Hence outbreaks of yellow fever in the North are checked naturally as winter approaches, and with our present knowledge of the method of control of this disease it is not probable that it will be permitted to become epidemic again in the United States.

The yellow-fever mosquito breeds in cisterns, water-barrels, flower-vases, and in the various water receptacles about houses. The life-cycle under favorable conditions is completed in from twelve to fifteen days. This is essentially a domesticated species. It is rarely found far from the habitations of man.

Anŏpheles. — To this genus belong those mosquitoes that have been found to be the carriers of malaria. At least four species of *Anopheles* in the United States, are known to be carriers of this disease. In this genus the palpi of both sexes are nearly or quite as long as the proboscis and the wings are frequently spotted. When at rest on a vertical wall the body is usually held at an angle with the vertical. Some species often enter houses. They hibernate in the adult state and can be found during the winter in cellars.

The larva when at rest floats in a horizontal position beneath the surface film (Fig. 516). There is no respiratory tube but instead a flattened area on the eighth abdominal segment into which the two spiracles open.

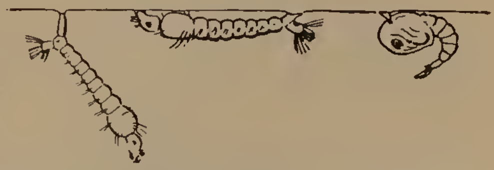

Fig. 516. — Normal position of the larvæ of *Culex* and *Anopheles* when at rest. *Culex*, left, *Anopheles*, middle; *Culex* pupa, right hand figure.

Other mosquito-borne diseases of man.—In tropical countries there are, in addition to malaria and yellow fever, two other diseases of man that have been found to be transmitted by mosquitoes; these are *dengue* and *filarīasis*. The latter disease is accompanied by extraordinary deformities and enlargements of different parts of the human body known as *elephantīasis*. Filariasis is due to the presence in the blood, the lymphatics, and certain tissues of the body, of nematode (round) worms of the family, Filariidae. These worms pass a part of their life-cycle in the bodies of certain mosquitoes.

Family Mycetophilidæ

The Fungus-gnats

These flies are of medium or small size, and more or less mosquito-like in form. They are most easily recognized by the great length of the coxæ (Fig. 517), and the fact that all the tibiæ are furnished with spurs. They also differ from the closely-allied families in lacking whorls of hairs on the antennæ of the males (Fig. 518), and in possessing ocelli.

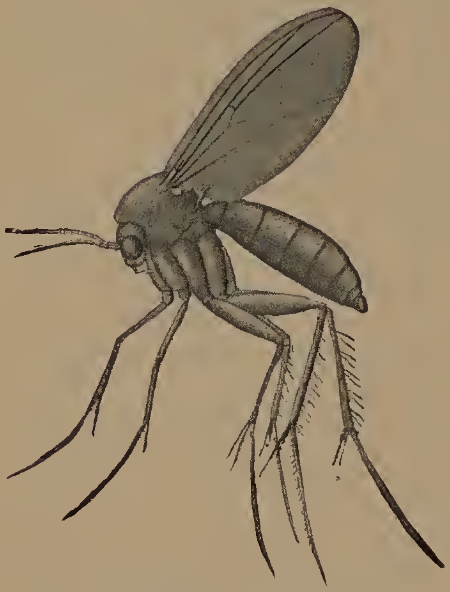

Fig. 517. — A fungus-gnat. (After Johannsen.)

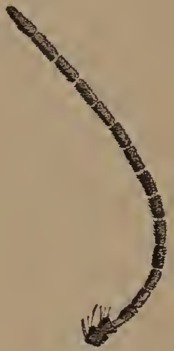

Fig. 518. — An antenna of a male fungus-gnat.

The fungus-gnats are exceedingly numerous both in number of individuals and in number of species. They are often found in great numbers on fungi and in damp places where there is decaying vegetable matter. They are active and leap as well as fly.

The larvæ of most species live upon and destroy mushrooms, usually the wild plants, but sometimes they are pests in mushroom cellars; other species are found in decaying wood.

The larvæ of the fungus-gnats are more or less cylindrical, smooth, soft, whitish in color, and with small strongly chitinized heads which are usually brown or black, and are provided with mandibles and maxillæ. There are usually eight pairs of spiracles.

The pupa is not enclosed in the skin of the larva; but in some genera the transformations are undergone in a delicate cocoon.

The larvæ of some species of the genus *Sciara* often attract attention on account of a strange habit they have of sticking together in dense patches. Such assemblages of larvæ are frequently found under the bark of trees. But what is more remarkable is the fact that when the larvæ are about to change to pupæ an assemblage of this kind will march over the surface of the ground, presenting the appearance of a serpent-like animal. Such a congregation is commonly spoken of as a Sciara-army-worm. Examples have been described that were four or five inches wide and ten or twelve feet long, and in which the larvæ were piled up from four to six deep. The larvæ crawl over each other so that the column advances about an inch a minute.

Some species of Sciara are sometimes injurious to house plants and to plants in greenhouses for their larvæ live in the soil and eat off the roots of the plants.

Family CECIDOMYIDÆ

The Gall-gnats

The gall-gnats are minute flies which are extremely delicate in structure. The body and wings are clothed with long hairs, which are easily rubbed off. The antennæ are usually long and clothed with whorls of hairs (Fig. 519); but they vary greatly in length and in the number of their segments. The legs are slender and quite long, but the coxæ are not greatly elongated and the tibiæ are without spurs.

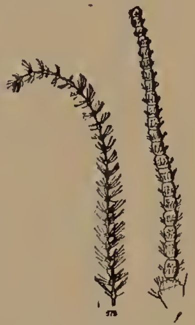

FIG. 519. — Antennæ of gall-gnats; *m*, male; *f*, female, enlarged more than that of the male.

In most, the wing-veins are greatly reduced in number, the anal veins being entirely wanting.

To this family belong the smallest of the midge-like flies. The larvæ of many species cause the growth of galls on plants. Other species arrest the growth of the plants they infest, and cause very serious injury.

The larvæ are small maggots, with nine pairs of spiracles. The head is small, poorly developed, and without mandibles. Many species are brightly colored, being red, pink, yellow, or orange, and many species possess in the last larval instar a peculiar chitinous organ on the ventral aspect of the prothorax; this organ is known as the *breast-bone* or *sternal spatula*, or *anchor process* (Fig. 520). It varies in form in different species; different views are held regarding its function, none of which seems well established.

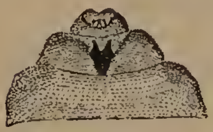

FIG. 520. — Head-end of larva showing the breast-bone.

The larval mouth-parts are fitted only for taking liquid food; but the nature of this food differs greatly in different members of the family. Some suck the juices from the bodies of living aphids, coccids, mites, and larvæ and pupæ of other flies; but most live on the juices of plants.

The different species vary as to the method of undergoing their transformation; in some the pupa is naked; in others the pupa is enclosed in the dried skin of the larva; and in still others it is enclosed in a delicate cocoon.

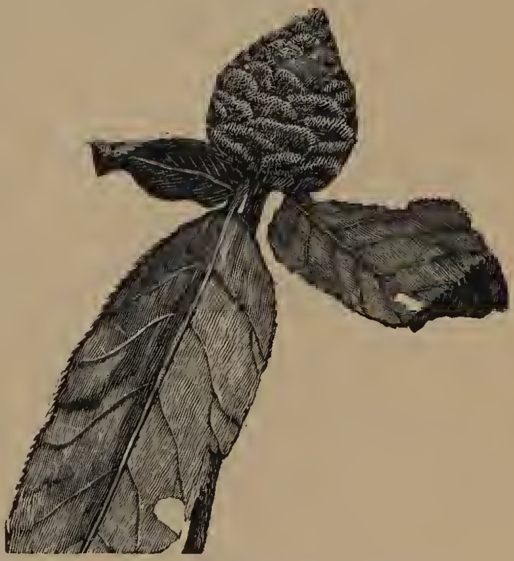

FIG. 521. — The pine-cone willow-gall.

One of the most conspicuous of the galls made by gall-gnats is the pine-cone willow-gall (Fig. 521). This often occurs in abundance on the tips of twigs of the heart-leaved willow, *Salix cordata*. The gnat that causes the growth of this gall is *Rhabdŏphaga strobiloides*. The larva remains in the heart of the gall throughout the summer and winter, changing to a pupa early in the spring. The adult emerges soon afterward, and lays its eggs in the newly-started buds of the willow.

The clover-flower midge, *Dasyneura leguminĭcola*, is a very serious pest. The larvæ live in the heads of clover and destroy the immature seed. Different kinds of clover are infested by this pest; but red clover is its chief food plant.

The larva of the clover-flower midge passes the winter on or slightly below the surface of the ground, usually but not always, in a cocoon; it changes to a pupa early in the spring, and emerges an adult in late April or early May. The eggs are laid in the small green clover heads, many eggs in a single head, as each larva infests a single floret. The larvæ mature in about four weeks, and then drop to the ground to transform. Two or three weeks later a second generation of midges appear and lay their eggs.

The Hessian-fly, *Phytŏphaga destrŭctor*, is the most serious pest infesting wheat in this country. The larvæ live at the base of a leaf between it and the main stalk, where they draw their nourishment from the plant. There are two or three broods of this insect in the course of the year. The larvæ of the fall brood infest the young wheat plants near the surface of the ground. When full-grown each changes to a pupa within a brown puparium, which resembles a flaxseed. Here they remain throughout the winter. In the spring the adult gnats emerge and lay their eggs in the sheaths of leaves some distance above the ground. The infested plants are so weakened by the larvæ that they produce but little if any seed, and often bend or even break off at the weakened spot.

The wheat-midge, *Thecodiplōsis mosellāna*, is also a very serious enemy of wheat. It deposits its eggs in the opening flowers of wheat. The larvæ feed on the pollen and the milky juice of the immature seeds, causing them to shrivel up and become comparatively worthless. When full-grown the larvæ drop to the ground, where the transformations are undergone near the surface. The adults appear in May or June.

The pear-midge, *Contarĭnia pyrĭvora*, deposits its eggs by means of a long ovipositor, in the interior of the unopened blossoms of pear. The young fruit is destroyed by the larvæ. There is a single annual generation. The winter is passed in the ground, usually as pupæ but sometimes as larvæ.

The chrysanthemum gall-midge, *Diarthronomȳia hypogæa*, causes the growth of galls on the leaf, stem, and flower-head of the chrysanthemum plant, and is sometimes a serious pest in greenhouses.

There are a few species of gall-gnats that are remarkable for their mode of reproduction. The larvæ of these gnats which live beneath the bark of decaying trees give birth to living larvæ. Such a type of reproduction is known as *pædogenesis*.

Family BIBIONIDÆ

The March-flies

In this family the abdomen is often comparatively robust, and the legs shorter and stouter than in most of the families with thread-like antennæ (Fig. 522). The antennæ are rarely longer than the head and thorax, and composed of short, broad, and closely-pressed-together segments (Fig. 523).

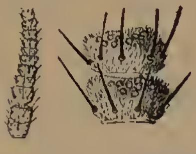

FIG. 523. — Antenna of *Bibio.*

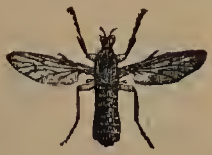

FIG. 522. — *Bibio.*

The adult flies are generally black and red, sometimes yellow or wholly black. They are most common in early spring; which has suggested the name March-flies; but some occur later in the season, and even in the autumn.

The larvæ vary in habits; some species feed on decaying matter, while others attack the roots of growing plants, especially of grass. They have ten pairs of spiracles, which is a rather large number, although there are other insects that have as many. The pupæ are usually free.

The subfamily, *Scatopsinæ*, includes a few species of minute black flies which are from $\frac{1}{25}$ to $\frac{3}{25}$ of an inch in length. Most of the known larvæ live in excrement.

Family SIMULIIDÆ

The Black-flies

The common name, black-flies, given to the members of this family is not distinctive, for there are many species of other families that are of this color. It is like the word blackberry; some blackberries are white, and not all berries that are black are blackberries.

In this family the body is short and stout; the thorax is much arched, giving the fly a humpbacked appearance (Fig. 524); and the legs are comparatively short. The antennæ are scarcely longer than the head and are eleven-jointed; the segments are short and closely pressed together (Fig. 525); they are clothed with fine hairs. The ocelli are absent. In the male the eyes are very large and contiguous, and divided; the upper half of each has the facets very much larger than the lower, from which they are distinctly divided by a horizontal line. In the female, the eye facets are of almost uniform size; and the two eyes are widely separated.

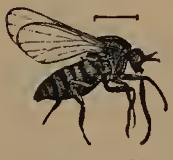

FIG. 524. — *Simulium.*

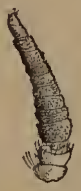

FIG. 525.

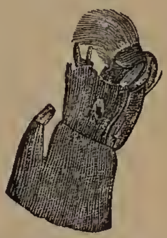

FIG. 526. — Head of larva.

The larvæ are aquatic; and usually live in swiftly-flowing streams, clinging to the surface of rocks in rapids or on the brinks of falls. They sometimes occur in such large numbers as to form a moss-like coating over the rocks. There is a disk-like sucker fringed with little hooks at the caudal end of the body by means of which the larva clings to the rocks; and just back of the head there is a fleshy proleg which ends in a similar sucker fringed with hooks (Fig. 526). Respiration is accomplished by means of blood-gills. The head bears two large fan-shaped organs, which aid in procuring food. The food consists chiefly of algæ and diatoms.

When full-grown the larva spins a cocoon within which the pupal state is passed (Fig. 527). This cocoon is firmly fastened to the rock upon which the larva has lived or to other cocoons, for they occur in dense masses, forming a carpet-like covering on the rocks. The pupa breathes by tracheal gills which are borne on the prothorax.

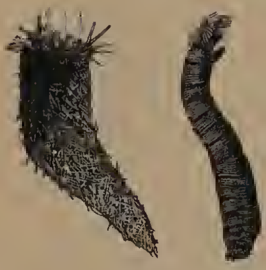

Fig. 527.—Cocoon and larva.

The adult fly, on emerging from the pupa-skin, rises to the surface of the water and takes flight at once. Soon after this the eggs are laid. Sometimes the eggs are laid under water attached to rocks and sometimes on blades of grass, twigs or leaves which are dipping in the water.

The females of many species suck blood and are well-known pests. Unlike mosquitoes and midges, the black-flies like heat and strong light. They are often seen in large numbers disporting themselves in the brightest sunshine.

The species that have attracted most attention in the United States are the following.

The Adirondack black-fly, *Prosimūlium hĭrtipes*, is a widely distributed species but it has attracted most attention in the mountains of the Northeastern States, where fishermen find it to be a scourge in May and June. In this species the radial sector is distinctly forked.

The southern buffalo-gnat, *Eusimulium pecuārum*, is the "Buffalo-gnat" of the Mississippi Valley, which in the past has been a terrible pest of mules and other domestic animals, sometimes causing their death; but it seems to be much less common now than in former years. In this species the radial sector is very indistinctly forked at the apex. The popular name of this insect refers to a fancied resemblance in the shape of the insect when viewed from one side to that of a buffalo.

The turkey-gnat, *Simūlium meridionāle*, closely resembles the preceding in habits, infesting all kinds of domestic animals, especially in the Mississippi Valley. As it appears at the time that turkeys are setting and causes great injury to this fowl, it is commonly known as the turkey-gnat. In this species the radial sector is not forked.

The white-stockinged black-fly, *Simūlium venūstum*, is widely distributed and is one of the more common species of the genus. It can be distinguished from the other species mentioned here by the fact that the tibiæ are silvery white above. In the Adirondacks it appears later than *Prosimulium hirtipes* and is not so serious a pest. Professor Needham writes: "Guides have a saying, that, when the black-flies put on their white stockings in June, the trouble is about over. This species has the white stockings."

The innoxious black-fly, *Simūlium pĭctipes*, is very widely distributed and at Ithaca it is our most common species.

Family Blepharoceridæ

The Net-winged Midges

The net-winged midges are extremely remarkable insects; for in certain respects the structure of the adults is very peculiar, and the larvæ appear much more like crustaceans than like insects.

The adults are mosquito-like in form; but they differ from all other insects in having the wings marked by a network of fine lines which extend in various directions and are not influenced at all by the veins of the wing (Fig. 528). They are, however, quite constant in their position in the species studied.

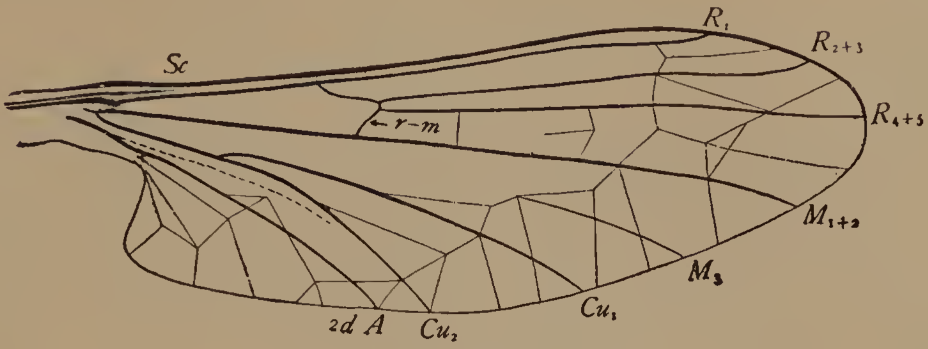

Fig. 528. — Wing of *Blepharocera tenuipes*.

When a wing is examined with a microscope, the fine lines are seen to be slender thickenings extending along the courses of slight folds in the wing. The wing in the pupal sheath is plaited like a fan and folded along these fine lines so that all the insect has to do when it issues from swiftly flowing water is to unfold the wing quickly and take flight at once. Most insects have to wait for a time to allow the wings to expand and dry before they can fly.

The immature forms of these insects are even more wonderful than are the adults. The larvæ live in water, in swiftly-flowing streams, where the water flows swiftest. They are readily seen on account of their black color.

The body consists of seven large segments alternating with five smaller ones. Most of the larger segments bear a pair of conical, leg-like appendages, a sucker on the ventral side for clinging to the rocks, and tufts of tracheal gills.

The pupæ occur in the same place as the larvæ closely attached by suckers to the rocks. They are black and conspicuous and often clustered close together. On the dorsal side of the pupa the skin is hard, forming a convex scale over the body (Fig. 529); and the thorax bears a pair of breathing organs.

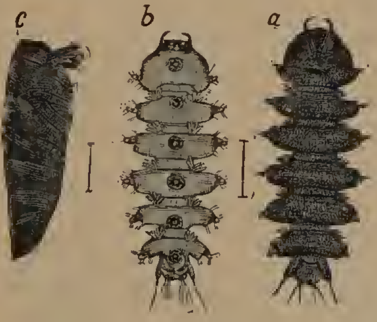

Fig. 529. — *Blepharocera*. *a*, larva, dorsal view; *b*, larva, ventral view; *c*, puparium.

Since the larvæ of the net-winged midges live only in swift-flowing streams, they are found only in mountainous or at least hilly regions. It is believed that they feed chiefly on algæ and diatoms. It does not seem probable that these delicate midges can deposit their eggs on the rocks in the swift-running water where the larvæ live. It is more likely that the eggs are deposited on the wet rocks at the margins of the stream and that the larvæ migrate to the center of the stream. There are not many species of these midges but they are found around the world, from the Americas to Europe, Australia, and New Zealand.

SERIES II. STRAIGHT-SEAMED FLIES WITH SHORT ANTENNÆ. (*Brachycera*) *

Family Tabanidæ

The Horse-flies

The horse-flies are well-known pests of stock, and are often extremely annoying to man. They appear in summer, are common in woods, and are most abundant in the hottest weather.

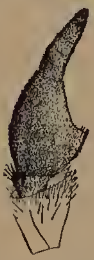
Fig. 530.— Antenna of *Tabanus*.

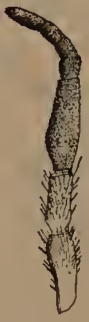
Fig. 531.— Antenna of *Chrysops*.

In this family the flagellum of the antennæ is composed of from four to eight, more or less closely consolidated segments and is never furnished with a distinct style or arista (Figs. 530, 531). The venation is shown in Figure 532.

The flight of these flies is very powerful, they are able to outstrip the swiftest horse. The males feed on the nectar of flowers and on sweet sap. The mouth-parts of the female are fitted for piercing the skin and sucking the blood of men and quadrupeds; the females, however, also feed on sweets of plants when they cannot obtain blood.

The larger species, as well as some of moderate size, belong to the genus *Tabānus* of which nearly two hundred species are listed from North America. One of the most common of these is the mourning horse-fly, *Tabānus atrātus*. This insect is of uniform black color throughout, except that the body may have a bluish tinge (Fig. 533). The species of this genus attack cattle and other farm animals almost exclusively.

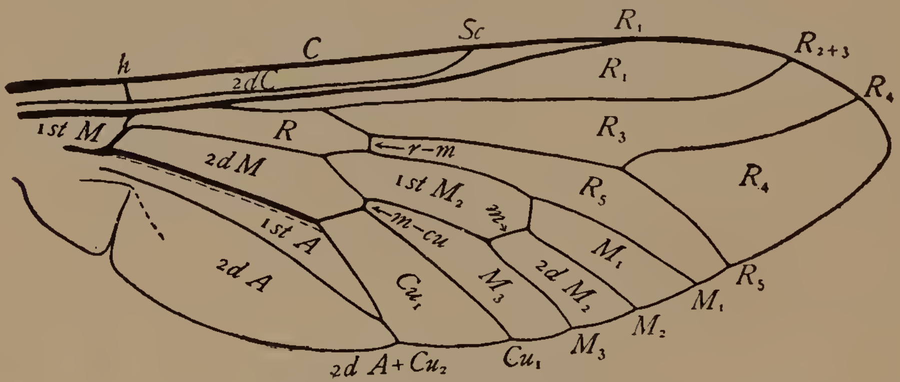

Fig. 532. — Wing of *Tabanus*.

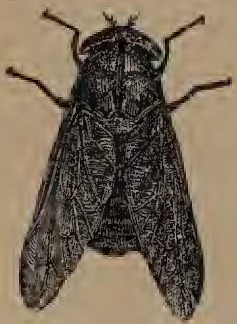
Fig. 533. — *Tabanus atratus*.

To the genus *Chrȳsops* belong the smaller and more common horse-flies with banded wings (Fig. 534). The species of this genus attack man as well as other animals. To this genus belong the well-known deer-flies familiar to fishermen and hunters. The eggs are deposited in masses on plants or on exposed stones in the bed of a stream.

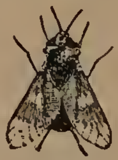
Fig. 534. — *Chrysops niger*.

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* Brachȳcera: *brachy*, short; *ceras* (κερας), a horn.

The larvæ are aquatic or semi-aquatic. As far as known, they are predacious, feeding on various small animals, some upon snails, others upon the larvæ of insects.

Family STRATIOMYIDÆ

The Soldier-flies

The soldier-flies are so called on account of the bright-colored stripes with which some of the species are marked. In the more typical members of this family the abdomen is broad and greatly flattened (Fig. 535), and the wings when at rest lie parallel upon each other over the abdomen (Fig. 536).

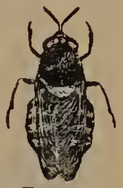

FIG. 535. — *Stratiomyia.*

The antennæ vary greatly in form, in some genera the flagellum is long and consists of several quite distinct segments (Fig. 537), in others it is short with but few indistinctly separated segments and with an arista (Fig. 538).

The larvæ are spindle-form or elliptical and flattened. Some are aquatic, some live in cow-manure and some under the loosened bark of trees.

There are three small families of flies, the *Xylomyidæ*, *Xylophagidæ*, and *Cœnomyidæ* which occur in the series here and which the student will find discussed in detail in "An Introduction to Entomology" by J. H. Comstock pp., 832, 833, and 834.

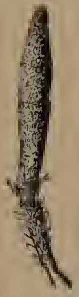

FIG. 537.

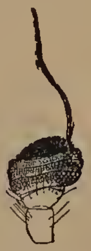

FIG. 538.

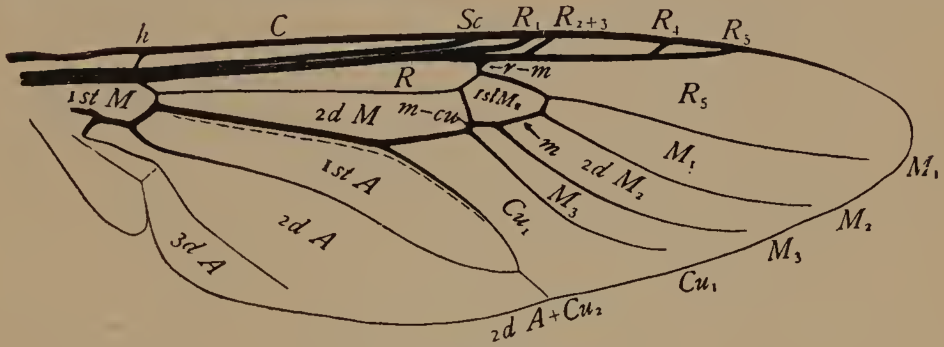

FIG. 536. — Wing of *Stratiomyia.*

Family RHAGIONIDÆ

The Snipe-flies

These trim-appearing flies have rather long legs, a cone-shaped abdomen tapering towards the hind end (Fig. 539) and sometimes a downward-projecting proboscis, which with the form of the body and legs has suggested the name snipe-flies.

The body is naked or hairy, but it is not clothed with strong bristles. Frequently the hairy covering, though short, is very dense and is of strongly-contrasting colors. Three ocelli are present. The antennæ are only three-jointed and the third segment bears a style or an arista (Fig. 540).

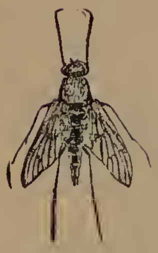

FIG. 539. — *Chrysopila thoracica.*

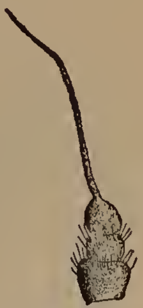

FIG. 540. — Antenna of *Chrysopila.*

The proboscis is usually short, only a few members of the family having it long like the bill of a snipe. The wings are broad, and when at rest are held half open. The empodia are pulvilliform (Fig. 541).

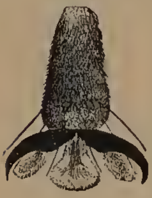

FIG. 541.

The flies are usually of moderate size. They may be found about low bushes and on tall grass. They are sometimes sluggish and, therefore, easily caught.

Large masses of these flies have been observed in various parts of this country; and formerly, in the far West, they were collected by the Indians and used for food after being cooked. It is said that as many as a hundred bushels of flies could be collected in a single day.

The larvæ of this family are found in various situations; some live in water, but a larger number live in earth, in decaying wood, or in sand.

Family ACROCERIDÆ

The Small-headed Flies

These flies are easily recognized by the unusually small head, the large humpbacked thorax, the inflated abdomen, and the very large alulets (Fig. 542). The body is devoid of bristles and the empodia are pulvilliform.

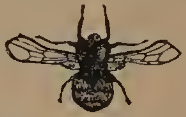

FIG. 542. — *Pterodontia misella.*

The head is composed almost entirely of eyes, and in some genera is minute. The eyes are contiguous in both sexes or nearly so. The antennæ are three-jointed, and are furnished with a style or an arista in some genera, in other genera the style and arista are absent.

The flies are generally slow and feeble in their movements. In some species that feed upon flowers the proboscis is very long, sometimes exceeding the body in length. Other species take no nourishment in the adult state, and have no proboscis.

The larvæ of only a few members of this family have been observed; these are parasitic in the egg-sacs or in the bodies of spiders.

Family BOMBYLIIDÆ

The Bee-flies

These flies are mostly of medium size, some are small, others are rather large. In some the body is short and broad and densely clothed with long, delicate hair (Fig. 543). Other species resemble the horse-flies somewhat in appearance, especially in the dark color or markings of the wings; but these can be distinguished from the horse-flies by the form of the antennæ and the venation of the wings.

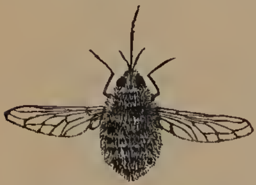

FIG. 543. — *Bombylius.*

The antennæ are usually short; they are three-jointed and with or without a style. The ocelli are present. The proboscis is sometimes very long and slender, and sometimes short and furnished with fleshy lips at the extremity.

The adult flies feed on pollen and nectar, and are found hovering over blossoms, or resting on sunny paths, sticks or stones; they rarely alight on leaves. The larvæ are parasitic infesting hymenopterous and lepidopterous larvæ and pupæ and the egg-sacs of Orthoptera.

Family THEREVIDÆ

The Stiletto-flies

With the flies of this family the head is transverse, being nearly as wide as the thorax; and the abdomen is long and tapering, suggesting the name stiletto-flies. These flies are small or of medium size; they are hairy or bristly. The antennæ are three-jointed; the third segment is simple, and usually bears a terminal style. The legs are slender and bristly; the empodia are wanting. It is a small family.

The adult flies are predacious; they conceal themselves among the leaves of low bushes or settle on the ground in sandy spots, waiting for other insects, chiefly Diptera, upon which they prey.

The larvæ are long and slender, and the body is apparently composed of nineteen segments. They are found in earth, fungi, and decaying wood.

Family SCENOPINIDÆ

The Window-flies

The window-flies are so-called because the best-known species are found almost exclusively on windows; but the conclusion that these are the most common flies found on windows should not be drawn from this name; for such is not the case.

These flies are of medium size, our most common species measuring $\frac{1}{4}$ of an inch in length. They are usually black, and are not clothed with bristles. The thorax is prominent, and the abdomen is flattened and somewhat bent down, so that the body when viewed from the side presents a humpbacked appearance (Fig. 544). When at rest, the wings lie parallel, one over the other, on the abdomen. The antennæ are three-jointed; the first and second segments are short, the third is long and bears neither a style nor an arista (Fig. 545).

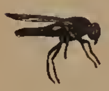
FIG. 544.—*Scenopinus.*

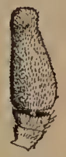
FIG. 545.

The larvæ, which are sometimes found in dwellings under carpets or in furniture, are very slender, and are remarkable for the apparently large number of the segments of the body, each of the abdominal segments except the last being divided by a strong constriction. They are also found in decaying wood, and are supposed to be carnivorous.

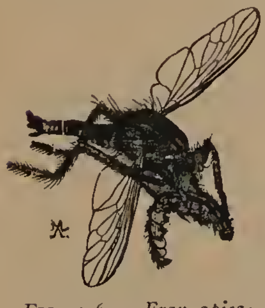
FIG. 546.—*Erax apicalis* destroying a cotton-worm. (From the Author's Report for 1879.)

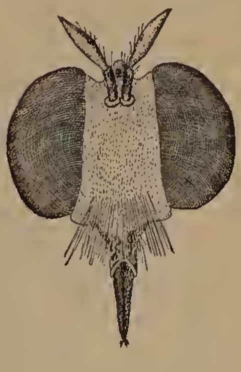
FIG. 547.—Head of robber-fly.

Family ASILIDÆ

The Robber-flies

These are mostly large flies, and some of them are very large. The body is usually elongate, with a very long, slender abdomen (Fig. 546); but some species are quite stout, resembling bumblebees in form and coloring.

The vertex of the head is hollowed out between the eyes (Fig. 547). In this family the proboscis is pointed and does not bear fleshy lips at the tip. The antennæ are three-jointed, and with or without a terminal style.

The robber-flies are extremely predacious. They not only destroy other flies, but powerful insects, as bumblebees, tiger-beetles, and dragonflies, fall prey to them; they will also feed upon larvæ. They are common in open fields and are as apt to alight on the ground as on elevated objects.

The larvæ live chiefly in the ground or in decaying wood, where they prey upon the larvæ of other insects; some, however, are supposed to feed upon the roots of plants. The pupæ are free.

More than five hundred North American species of this family, representing seventy-five genera, have been described.

Family Mydaidæ

The Mydas-flies

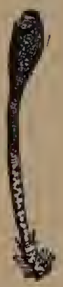
Fig. 548.

The mydas-flies rival the robber-flies in size, and quite closely resemble them in appearance. As in that family, the vertex of the head is hollowed out between the eyes; but these flies can be distinguished by the form of the proboscis, which bears a pair of fleshy lobes at the tip, by the form of the antennæ, which are four-jointed, long and more or less clubbed at the tip (Fig. 548) and by the peculiar venation of the wings (Fig. 549).

The adults are said to be predacious. The larvæ of some species, at least, live in decaying wood, and some are known to prey upon the larvæ of beetles.

The family is a small one; but it includes the largest flies in the Diptera.

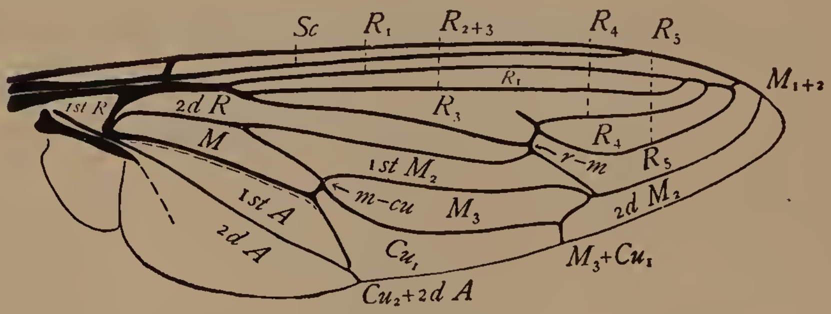

Fig. 549. — Wing of *Mydas.*

Family Dolichopodidæ

The Long-legged Flies

These flies are of small or medium size and usually bright metallic green or blue in color. The legs are much longer than is usual in the related families but not as long of course as in the crane-flies. The family is a very large one.

The members of this family are easily distinguished as such by the peculiar venation of the wings (Fig. 550).

The members of this family have three ocelli; the antennæ are three-jointed; the second segment of the antennæ is sometimes vestigial and the third segment bears an arista; the palpi are one-jointed; and the empodia are not pulvilliform.

The adults are predacious and hunt for smaller flies and other soft-bodied insects. They are usually found in damp places, covered with rank vegetation. Some species occur chiefly on the leaves of aquatic plants, and about dams and waterfalls; and some are able to run over the surface of water. Others occur in dry places.

The larvæ live in a variety of situations, some in earth or decomposing vegetable matter, some in the burrows of wood-boring larvæ and also under bark; some in the stems of plants; and a few are aquatic. But little is known regarding the habits of the larvæ; it is said that some species feed on decaying vegetation, while others are believed to be predacious.

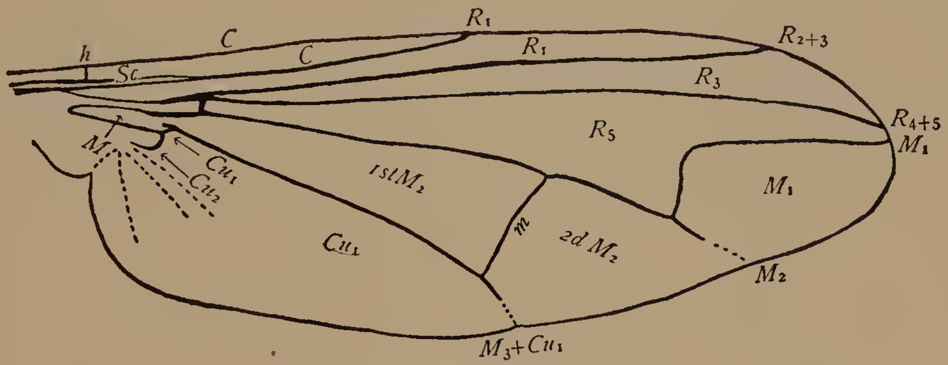

FIG. 550. — Wing of *Psilopodius sipho*.

Family EMPIDIDÆ

The Dance-flies

The dance-flies are of medium or small size; they are often seen in swarms flying with an up and down movement under trees or near shrubs and over the surface of water. These flies are predacious, like the robber-flies, but they also frequent flowers. The family is a rather difficult one to characterize owing to great variations in the form of the antennæ and in the venation of the wings (Fig. 551).

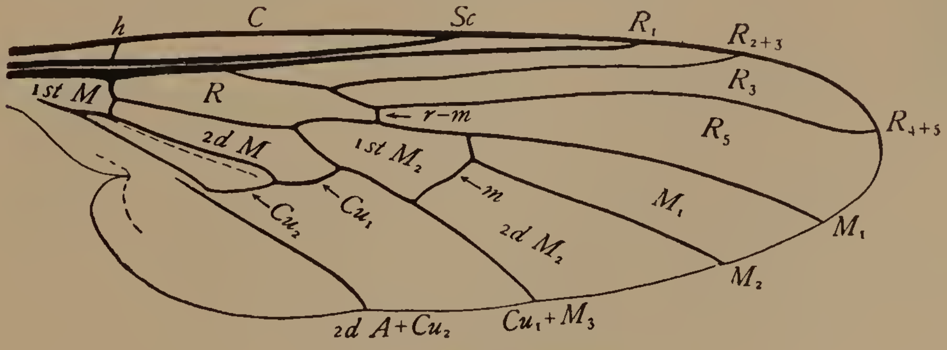

FIG. 551. — Wing of *Rhamphomyia*.

The larvæ live in various situations, some in the ground or in decaying wood, and some species are aquatic; they are believed to be either predacious or scavengers. The pupæ are free.

This family is a large one.

Family LONCHOPTERIDÆ

The Spear-winged Flies

These are minute flies, which measure from $\frac{1}{12}$ to $\frac{1}{6}$ of an inch in length, and are usually brownish or yellowish but never green nor metallic in color. When at rest the wings are folded flat, one over the other, on the abdomen. The apex of the wing is pointed, and the wing as a whole is shaped somewhat like the head of a spear (Fig. 552). This suggested the family name.

The venation of the wings is very characteristic, and is sufficient to distinguish these flies from all others.

These flies are common from spring till autumn, in damp grassy places. They frequent the shores of shady brooks, where the atmosphere is moist. The males are very rare in this country.

"The larvæ live under leaves and decomposed vegetable matter."

The family includes a single genus, *Lonchŏptera*.

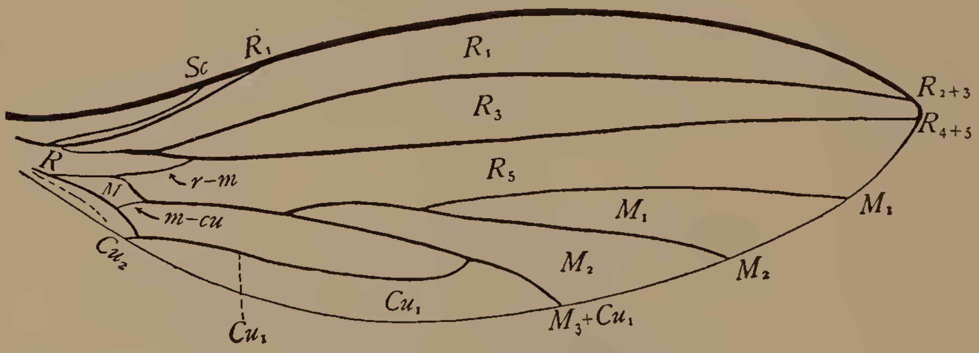

FIG. 552. — Wing of *Lonchoptera*, female.

Suborder CYCLORRHAPHA*

The Circular-seamed Flies

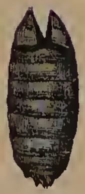

FIG. 553. — Puparium of a muscid.

To this suborder belong those families of flies in which the pupa is always enclosed in a puparium from which the adult escapes through a round opening made by pushing off the head-end of it. (Fig. 553); the cap thus pushed off is often split lengthwise, as shown in the figure. The adult flies possess a frontal lunule and except in the first three families a frontal suture, through which the ptilinum is pushed out, when the adult is about to emerge from the puparium. The antennæ are usually three-jointed and nearly all have a terminal or dorsal arista, — rarely with a terminal style.

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* Cyclŏrrhapha: *cyclos*, (κύκλος), a circle; *rhaphe*, (ῥαφή), a seam.

SERIES I. CIRCULAR-SEAMED FLIES WITHOUT A FRONTAL SUTURE.
(*Aschiza*)

Family PHORIDÆ

The Humpbacked Flies

These are minute, dark-colored, usually black flies, which can be easily recognized by their humpbacked form, their peculiar antennæ, and the peculiar venation of the wings. Certain species are often found running about rapidly on windows, others on fallen leaves. Sometimes they are seen in swarms dancing up and down in the air.

The head is small; the thorax large and humped; and the abdomen rather short. The antennæ are three-jointed; but the first segment is exceedingly small, and the second is enclosed in the third, so that they appear as single-jointed. The third segment bears an arista. The legs are large and strong and well adapted to jumping. The wings (Fig. 554) are large, and are furnished with a series of strong veins near the costal border, which extend but a short distance beyond the middle of the wing.

In the females of some species that live in the nests of ants and termites the wings are absent or very much reduced in size.

The larvæ of the different species differ greatly in habits, some feed on decaying vegetable matter, dead insects, snails, etc.; some are common in mushrooms, and are sometimes a pest in mushroom cellars; some are internal parasites of other insects, as bees, wasps, ants, sawflies, etc.; several species are known to live in the nests of ants.

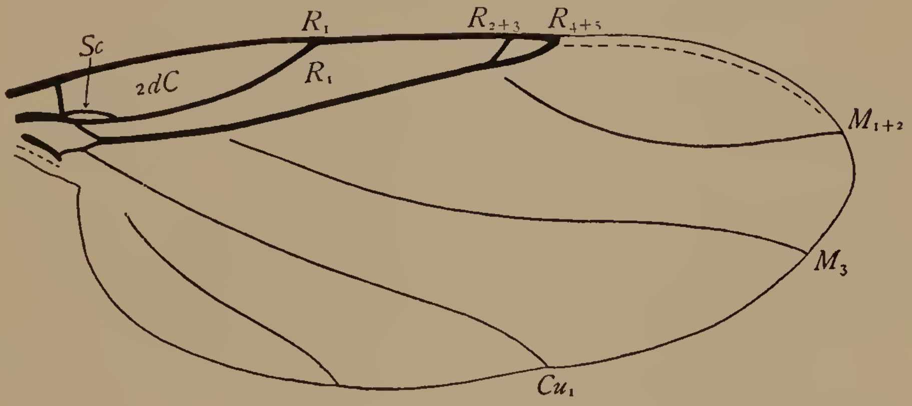

FIG. 554. — Wing of *Phora*.

Family PIPUNCULIDÆ

The Big-eyed Flies

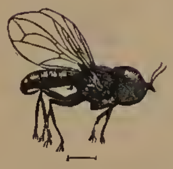

FIG. 555. — *Pipunculus*.

The members of this family are small flies with very large heads composed almost entirely of eyes (Fig. 555). The head is nearly spherical and broader than the thorax. The antennæ are small, short, three-jointed, with a dorsal arista. The ocelli are present. The abdomen is somewhat elongate with the sides nearly parallel. The body is thinly clothed with hair or nearly naked. The wings are much longer than the abdomen, and when at rest they lie parallel to each other upon it.

The flies hover in shady places. They are sometimes found on flowers, and may be swept from low plants; our most common species measure about $\frac{1}{8}$ of an inch in length, not including the wings. The larvæ so far as known are parasitic upon leafhoppers.

This small family is represented in North America by about thirty species, nearly all of which belong to the genus *Pipŭnculus*.

Family SYRPHIDÆ

The Syrphus-flies

The family Syrphidæ includes many of our common flies; but the different species vary so much in form that no general description of their appearance can be given. Many of them mimic hymenopterous insects, thus some species resemble bumblebees, others the honeybee, and still others wasps; while some present but little resemblance to any of these.

The most distinctive characteristic of the family is the presence of a thickening of the membrane of the wing, which appears like a longitudinal vein between veins R and M. This is termed the *spurious vein*, and is lacking in only a few members of the family; it is represented in Figure 556 by a band of stippling.

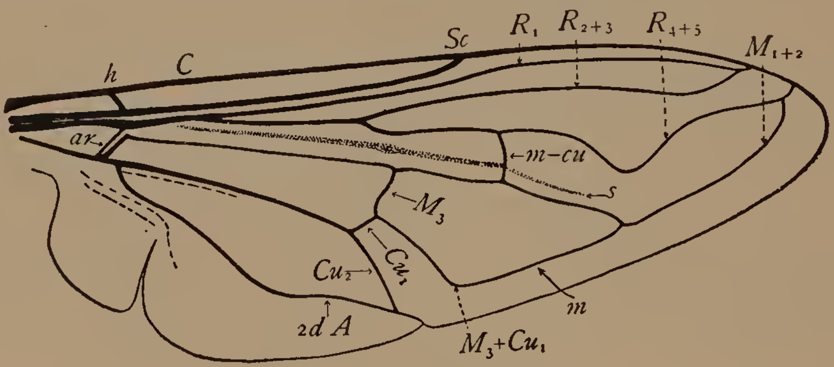

FIG. 556. — Wing of *Eristalis*.

The adults frequent flowers and feed upon nectar and pollen. Some fly with a loud humming sound like that of a bee, others hover motionless except as to their wings for a time, and then dart away suddenly for a short distance, and then resume their hovering.

The larvæ vary greatly in form and habits. Some prey upon plant lice, and are often found in the midst of colonies of these insects; some feed in the stems of plants and in bulbs; others feed on decaying vegetable matter, and live in rotten wood, in mud and in water; and others live in ordure or in decomposing animal remains. Some are found in the nests of ants; and some in the nests of bumblebees and wasps.

The larvæ of the genus *Volucĕlla* live as scavengers in the nests of bumblebees and of wasps (*Vespa*). Some of the species in the adult state very closely resemble bumblebees.

The larvæ of the genus *Mĭcrodon* are hemispherical, slug-like creatures (Fig. 557), which resemble mollusks more than ordinary maggots; they are common in ants' nests.

The larvæ of several species that live in water as well as some that live in rotten wood are known as rat-tailed maggots on account of the long, tail-like, air-tube with which the hind end of the body is furnished. This tube enables the insect to obtain air when its body is submerged beneath several inches of water or decaying matter. This tube being telescopic can be lengthened or shortened as the insect may need it; and at its tip there is a rosette of hairs, which, floating on the surface of the water, keeps the tip from being submerged.

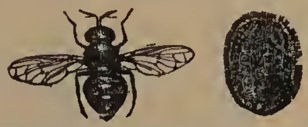
Fig. 557. — *Microdon*, adult and larva.

One of these "rat-tailed" maggots is the larva of the drone-fly, *Erĭstalis tenăx*. The maggot lives in foul water but obtains good air through its air-tube which projects up to the surface. The adult fly resembles a male honey-bee.

Among the more common members of this family are the yellow-banded species belonging to the genus *Syrphus* (Fig. 558). The larvæ of these live in colonies of aphids and do good by destroying these pests.

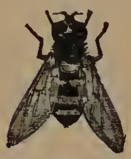
Fig. 558. — *Syrphus*.

SERIES II. CIRCULAR-SEAMED FLIES WITH A FRONTAL SUTURE.

(*Schizophora*)

The flies of the next eight of these families with a frontal suture have very small or rudimentary *alulæ* or *calypteres*. They are therefore known as acalyptrate flies or muscids.

Family Ortalidæ

This family like the Trypetidæ is a large one and contains many common species which have the wings beautifully marked with dark spots or bands.

Comparatively few species of the Ortalidæ have been bred and these differ greatly in habits. The larvæ of some have been found under bark of dead trees, others in excrement, some are parasitic on lepidopterous larvæ, and several infest growing plants. Among the latter are *Chætŏpsis ænea* and *Tritŏxa flexa* which sometimes infest onions.

Family Trypetidæ

This is a very large family including many common species with pictured wings, in which it resembles the preceding family, the Ortalidæ.

The larvæ of the species that have been bred infest living plants. Some are leaf-miners, some live in the stems of plants, some make galls, and some are pests that infest fruit. Among the better-known species are the following so-called fruit-flies.

The apple-maggot, *Rhagolētis pomonĕlla*. — The adult is blackish with the head and legs yellowish; the abdomen is crossed by three or four white bands (Fig. 559) and the wings are crossed by four dark confluent bands. The female punctures the skin of the apple with her ovipositor and lays her eggs in the pulp. The larvæ bore tunnels in all directions through the fruit. Early maturing varieties of apples are especially attacked. When full-grown the larva goes into the ground to transform where it hibernates in a brownish puparium.

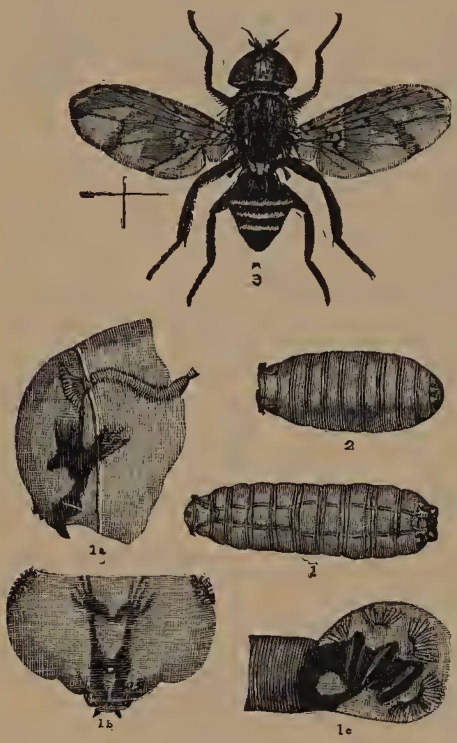

FIG. 559. — The apple-maggot: *1*, larva; *2*, puparium; *3*, adult; *1a*, head of larva from side, showing mouth-parts and cephalic spiracle; *1b*, head of larva from below; *1c*, caudal spiracle of larva.

The cherry-fruit flies, *Rhagolētis cingulāta* and *Rhagolētis fausta*. — These two species, which are closely allied to the apple-maggot, infest cherries.

The currant-fruit fly, *Epōchra canadĕnsis*. — The larva of this species is a small white maggot which feeds within currants and gooseberries. The infested fruit colors prematurely and usually falls to the ground.

The Mediterranean fruit-fly, *Ceratĭtis capitāta*, a cosmopolitan pest, has lately been discovered over a wide area in Florida. It is about the size of a housefly, yellowish in general color, and infests a multitude of fruits especially the citrus and stone fruits. The fly is a most serious pest in tropical and subtropical countries but will probably not prove of great economic importance in the northern portions of the United States.

The melon-fly, *Bactrocera cucŭrbitæ*, is another fruit-fly of Asiatic origin and now present in Hawaii. It attacks melons, squashes, and other cucurbits in a very destructive manner.

The round goldenrod gall. — One of the most familiar of abnormal growths on plants is a ball-like enlargement of the stem of goldenrod (Fig. 560). This is caused by a maggot, which lives within it, and which develops into a pretty fly with banded wings; this is *Eurŏsta solidăginis*. The larva hibernates in the gall; the adult emerges in May.

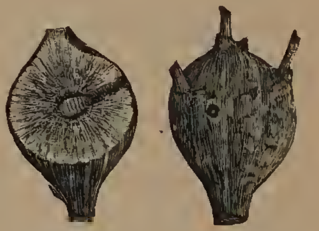

FIG. 560. — The round goldenrod gall.

Family PIOPHILIDÆ

This family includes only a few species of small flies, rarely exceeding $\frac{1}{5}$ of an inch in length. They are usually glistening black or slightly bluish-metallic in luster. They are found about either decaying organic matter, preserved meats, or cheese. The best-known species is the following.

The cheese-maggot, *Piŏphila cāsei*. — This fly lays its eggs on cheese, ham, and bacon. The larvæ live in these substances and are often serious pests. They are commonly known as "skippers" on account of the remarkable leaps they can make. This is accomplished by first bringing the head and tail ends together and then suddenly straightening the body; in this way they can leap several inches.

Family Psilidæ

The flies of this family are of moderate size and slender. In many of the species the antennæ are very long and decumbent, but in others they are of moderate length. The following is our best-known species.

The carrot rust-fly, *Psila rosæ.* — The larva of this species infests carrots, celery, parsnips, and parsley. In the case of carrots and parsnips the larvæ perforate the roots in all directions; their burrows are of a rusty color, hence the common name of the insect. When celery is attacked the fibrous roots are eaten off and destroyed.

Family Ephydridæ

These are small or very small, black or dark-colored flies, that live in wet places.

Most of the species live about fresh water; but to this family belong the "brine-flies" the larvæ of which live in salt or strongly alkaline waters. These are common in pools about salt-works; and in the far West and in Mexico these larvæ occur in the alkaline lakes in countless numbers. The best-known "brine-flies" belong to the genus *Ĕphydra.*

Still more remarkable are the habits of the larva of the petroleum-fly, *Psilōpa petrōlei,* which lives, feeds, and swims about in the pools of crude petroleum, which are numerous in the various oil-fields of California.

Family Chloropidæ

This family includes a considerable number of species that are common in meadows and other places where there is rank growing grass. In such situations they can be collected in large numbers by a sweep-net.

The members of this family are small bare species; with moderately short or very short wings.

The larvae of the different species differ in their habits; many species infest the stems of wheat, oats, rye, and grasses; some live in burrows in plants made by other insects; some live in excrement, while a few develop in the egg-sacs of spiders.

Among the more important members of this family is the following species.

The European frit-fly, *Ŏscinis frit.* — This is a minute black species, measuring from $\frac{1}{25}$ to $\frac{1}{12}$ of an inch in length. It was first described by Linnæus in Sweden, where it was a very serious pest of barley, the larvæ feeding upon the immature kernels. The light and worthless kernels resulting from this the Swedes called "frits," hence the common name of the species. There are several generations annually. The larvæ of the late fall generation winter as stem miners in winter grain; and spring grain is attacked in the same way by the spring generation. In this country the commonest form of injury is to the stems of wheat close to the ground. The larva of this species can be easily distinguished from the larva of the hessian fly by the fact that it works in the center of the stem and crawls actively when removed.

Family Drosophilidæ

The Pomace-flies and their Allies

There are certain small yellowish flies from $\frac{1}{8}$ to $\frac{1}{6}$ of an inch in length which are very common about the refuse of cidermills, decaying fruit, and fermenting vats of grape pomace; these are the pomace-flies (Fig. 561).

The larvæ of most species of this family, so far as is known, live in decaying fruit or in fungi; a few are leaf-miners.

One of the pomace-flies, *Drosŏphila melanogăster*, which is easily bred and which has a short life-cycle, is widely used in laboratories in the study of heredity. This species has been commonly known as *Drosŏphila ampelŏphila;* but *melanogaster* is the older specific name.

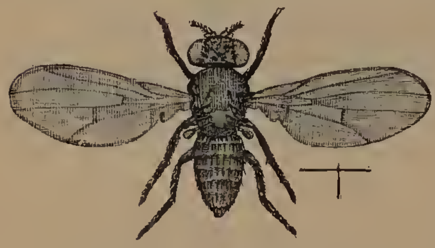

Fig. 561. — A pomace-fly.

Family Agromyzidæ

This family includes small or minute flies, most of which infest living plants. The larvæ form galls on the stems or mine in various parts of the plants, but principally in the leaves. A common species, *Phytomȳza aquilēgiæ*, makes serpentine mines in the leaves of wild columbine (Fig. 562). Other species mine in the leaves of oats, wheat, strawberries, asters, goldenrod, and blackberries, while one species, *Agromȳza maura* var *simplex*, is a pest to asparagus for the larvæ mine under the epidermis of the stems.

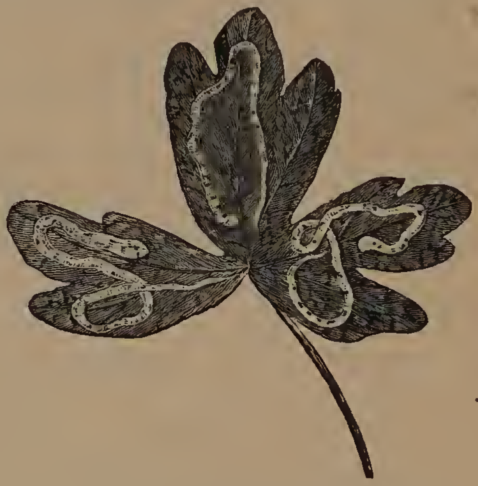

Fig. 562 — Mine of *Phytomyza aquilegiæ*.

The following eight families of those flies which have a frontal suture possess well developed *alulæ* or *calypteres*. They are therefore known as the calyptrate flies or muscids. To this group belong some of the most familiar flies, for example, the housefly and the flesh-flies.

Family Cordyluridæ

The Dung-flies

The members of this family are often of considerable size.

Although members of several families of flies frequent excrement, certain species of this family and of the Borboridæ are so commonly observed about dung and refuse that they have received the common names of dung-flies. Among these are those of the genus *Scatŏphaga;* these are rather slender flies, which have the body clothed with yellowish hair, and which are often abundant especially about fresh cow-dung. Other members of this family are found in meadows and in moist places; some feed on other insects which they capture.

The larvæ of some species have been bred from excrement; some live in the stems of plants; and some are said to be parasitic in caterpillars.

This family is named the Scatophagidæ by some writers.

Family ANTHOMYIDÆ

The Anthomyids

The anthomyids are very common flies of which about five hundred species have been described from North America. They are somewhat similar to the housefly in appearance but structurally distinct.

The larval habits are variable. Most species live in decaying vegetable matter; many live in excrement. A few species are parasitic within living insects and some attack growing plants. Among the latter are certain well-known pests of garden crops. The more important of these are the following.

The cabbage-root maggot, *Hylemȳia brăssicæ.* — This insect in its larval state feeds on the roots of cabbage, radish, turnip, and cauliflower; it also attacks the roots of various weeds belonging to the same family of plants. There are two or more generations of this pest each year. The first generation infests the young plants; the eggs of the second generation are laid late in June or in July. The maggots are especially injurious to cabbage plants in the seedbed and to early cabbage plants in the field.

The onion maggot, *Hylemȳia antīqua.* — The larva of this species is often exceedingly destructive to onions, destroying young plants in the spring, and when the plants are older, burrowing into the bulb and causing decay.

The beet or spinach leaf-miner, *Pegomȳia hyoscȳami.* — This leaf-miner infests the leaves of beets, sugar-beets, spinach, orach, mangels, and chard. The mine at first is thread-like but is soon enlarged to form a blotch. Several larvæ usually occupy the same leaf and their mines usually coalesce. There are several generations each year, and the winter is passed in the pupal state under fallen leaves in the soil.

The kelp-flies, *Fucĕllia.* — The larvæ of these flies live in brown seaweeds, cast up by waves along ocean beaches. The adults can be found all summer on the masses of these weeds often in immense numbers.

Family GASTEROPHILIDÆ

The Bot-flies of Horses

This family includes the well-known pests the larvæ of which infest the alimentary canal of horses and which are commonly known as bots. Three species are now well established in the United States and Canada. In the adult flies the oral opening is small and the proboscis vestigial.

The common bot-fly or the stomach bot, *Gasterŏphilus intestinālis.* — The adult fly closely resembles the honey-bee in form except that the female (Fig. 563) has the end of the abdomen elongate and bent forward under the body. The wings are transparent with dark spots, those near the center form an irregular, transverse band. This fly is most often seen flying about horses, which have an instinctive fear of it. The eggs are laid on different parts of the host, but preferably on the long hairs investing the inside of the fore legs. The eggs rarely hatch when left untouched; but the horse by scratching the fore legs with the teeth removes the small cap of the egg-shell and inadvertently takes the larva into its mouth. The larvæ thus taken into the mouth are carried with the food or water to the stomach. When the larvæ reach the stomach they fasten themselves to the inner coat of it, and remain there until full-grown. Then they pass from the animal with the dung, and crawl into some protected place, where they transform within a puparium.

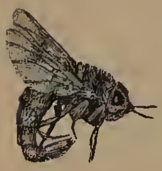
Fig. 563.

The chin-fly or the throat-bot, *Gasterŏphilus veterīnus*, is smaller than the common bot-fly and the wings are not marked with dark spots as in that species. The female usually deposits its eggs upon hairs under the jaws, and for this reason is commonly known as the chin-fly; but sometimes the eggs are laid upon the flanks or fore legs of the host.

The red-tailed bot-fly or the nose-fly, *Gasterŏphilus hæmorrhoidālis*, is easily distinguished by the bright orange-red tip of the abdomen. The wings are unspotted as in the chin-fly but differ from those of both of the preceding species in that the cross-vein m-cu is much farther from the base of the wing than is cross-vein r-m. The female oviposits on the lips of the horse; the flight of the fly about the nose of the horse when attempting to oviposit on its lips, suggested the common name, the nose-fly.

Family Œstridæ

Bot-flies (except Gasterŏphilus) and Warble-flies

This family includes flies that are large or of medium size; most of the species resemble bees in appearance; some, the honey-bee, others, bumblebees. The mouth-opening is small, and the mouth-parts are usually vestigial.

The larvæ are parasitic upon mammals; some develop in tumors under the skin and others, in the pharyngeal and nasal cavities of their hosts. As a rule each species infests a single species of mammal. In addition to the species that infest our domestic animals, other species infest rabbits, squirrels, deer, and reindeer. One that lives beneath the skin of the neck of rabbits is common.

The sheep bot-fly, *Œstrus ovis*. — This species is viviparous; the female fly deposits larvæ, which have hatched within her body, in the nostrils of sheep. The larvæ pass up into the frontal sinuses and into the horns when they are present. Here they feed upon the mucus. They are very injurious to sheep, causing vertigo or the condition known as "staggers." When full-grown they pass out through the nostrils and undergo their transformations beneath the surface of the ground.

The heel-fly, *Hypodĕrma lineātum*. — The adult fly is $\frac{1}{2}$ of an inch in length; the anterior part of the thorax is black and shining; the alulæ are uniformly white; and the tail end of the abdomen is reddish-orange

(Fig. 564). The eggs are laid mostly when the cattle are recumbent and on all parts which the fly can reach when it is resting on the ground.

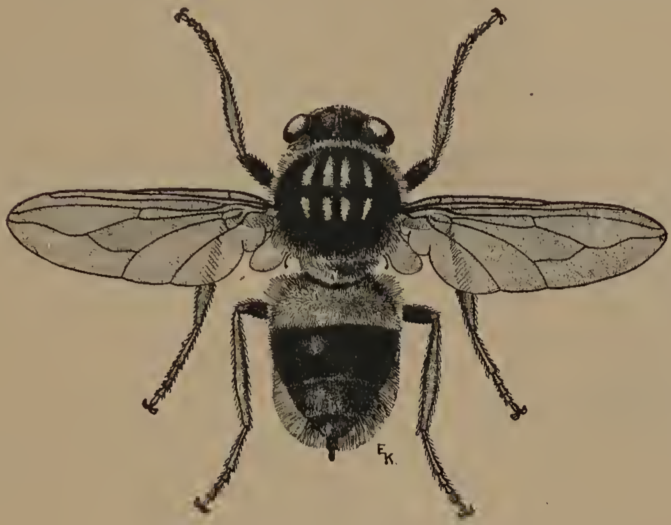

FIG. 564. — *Hypoderma lineatum.*

Even when the cows are standing the fly is able to lay eggs on those hairs which are close to the ground, namely on the heels.

The eggs hatch and the larvæ penetrate the skin at once and burrow their way, probably under the hide, to the neck. Here they enter the walls of the œsophagus and work down its tissues to the diaphragm and thence up the ribs to their resting places along each side of the backbone beneath the skin. Here each one forms a swelling or "warble." In the spring, each maggot works out through the hole in the hide, drops to the ground, pupates and in about 40 days emerges as a fly. This fly is especially troublesome to milch cows.

The bomb-fly, *Hypodĕrma bōvis.* — The adult fly measures a little over ½ an inch in length; there is yellow hair on the anterior part of the thorax; the alulæ are bordered with reddish-brown; and the tail end of the abdomen is orange-yellow. As a rule the flies lay their eggs while the cattle are running; the eggs are laid singly at the roots of the hairs; the flies are clumsy insects and strike at the animals blunderingly. The presence of one of these flies in a herd of cattle causes them to scatter and stampede. This species is prevalent in the North and is also annoying to milch cows.

Family CALLIPHORIDÆ

The Blow-fly Family

Certain members of this family are very familiar objects and are commonly known as blow-flies, bluebottle-flies, or greenbottle-flies. With these, and with most other members of the family as well, the body, especially the abdomen, is metallic-blue or green in color.

The larvæ of the different species vary in habits; some have been bred from cow-dung; some feed on fresh or decaying meat and on the bodies of dead animals; one frequently infests wounds on animals, and two are blood-sucking parasites of nestling birds. The following are our best-known species.

The blow-fly, *Callĭphora vomitōria*, is larger than the housefly, and black in color, with a steel-blue abdomen. It flies with a loud buzzing noise, and lays its eggs upon meat, cheese, and other provisions. The eggs hatch in about twenty-four hours, and the larvæ become full-grown in a few days.

The greenbottle-fly, *Lucĭlia cæsar*, is a common species which resembles the blow-flies in habits but it is smaller. The abdomen is sometimes bluish but more often greenish.

The screw-worm fly, *Chrysomyia macellaria*, is a bright metallic-green fly, with three black stripes on the thorax; it measures about one third of an inch in length. This pest resembles the flesh-flies in habits, and it deposits its eggs in wounds, sores, and the nostrils and ears of men and cattle. The larvæ living in these situations often cause serious sickness, and sometimes even death.

The cluster-fly, *Pollēnia rŭdis*, is so-called because of its habit of entering houses in the autumn and hiding away in protected nooks in large groups or clusters. It is a dark colored fly slightly larger than the housefly. The thorax bears many short golden hairs. Its larvæ are parasitic on earthworms.

Family SARCOPHAGIDÆ

The Sarcophagids

This family has been commonly known as the flesh-flies because some of them lay their eggs in bodies of dead animals, resembling in habits the blow-fly, which belongs to the family Calliphoridæ; but a wider knowledge of the habits of various members of this family shows that this name is misleading.

The Sarcophagidæ includes all of the Muscoid flies that agree in having the following characteristics: The coloration is gray or silvery, tessellated or changeable pollinose; vein M_{1+2} has an almost angular bend and ends considerably before the apex of the wing; the sides of the face are hairy; and the arista of the antennæ is plumose above and below for nearly half its length or a little more. None of the species has discal machrochætæ on the abdominal segments, hairy eyes, long proboscis, rudimentary palpi, or more than a single pair of discal scutellar bristles.

So far as is known all species of this family are larviparous. The different species show a wide range in larval habits; but by far the greater number of the species that have been bred are parasitic in other arthropods. They have been bred from various insects, from scorpions, and from the egg-sacs of spiders. Several species have been bred from dead fish; and a considerable number from the excrement of mammals. Five or six species live only in the tubular cups of pitcher-plants (*Sarracenia*), feeding on the dead insects found there. It has been found that *Sarcŏphaga hæmorrhoidālis* is sometimes the source of intestinal myiasis in man, and several cases of cutaneous myiasis caused by larvæ of *Wohlfăhrtia vigil* have been described.

If one wishes to determine the species of this family he should obtain the monograph, "Sarcophaga and allies in North America" by J. M. Aldrich, published in 1916.

Family TACHINIDÆ

The Tachina-flies

The tachina-flies are often found about flowers and rank vegetation. They are usually short, stout, and bristly (Fig. 565).

This is a very large family, more than fourteen hundred species are listed from North America alone; and from the standpoint of the agriculturist it is the most beneficial family of the Diptera.

This family includes four subfamilies; the Dexiinæ, Phasiinæ, Megaprosopinæ, and the Tachininæ, each of which is regarded as a separate family by some writers.

The larvæ are parasitic, chiefly within caterpillars, but they have been bred from members of several other orders of insects.

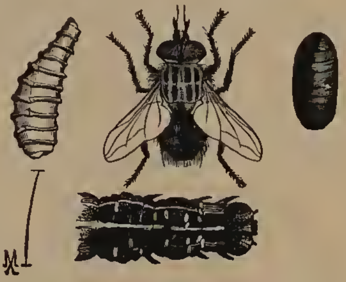

FIG. 565. — A tachina-fly. Larva, adult, puparium, and eggs upon the fore part of an army-worm.

The manner in which the larva finds its way into the body of its host differs greatly in different species of tachinids. In many species the female fastens her eggs to the skin of the caterpillar (Fig. 565); when the larvæ hatch they bore their way into their host and live there till they are full-grown. In some of the viviparous species the female punctures the skin of the caterpillar with the sheath of her ovipositor and deposits the larva within the body of the host. Some species deposit their eggs on the leaves of the food-plant of their host; these eggs are swallowed when the leaves are eaten.

Family MUSCIDÆ

The Typical Muscids

With these flies the bristle of the antenna is pubescent or plumose to the tip; but the abdomen is not bristly except near the tip. Here belong many of the best-known members of the Diptera. Among the more important ones are the following: —

The housefly, *Musca domĕstica*. — This is the most familiar representative of the order Diptera, as it abounds in our dwellings. It lays its eggs in horse-manure and in other decaying organic matter, a single female laying from one hundred and twenty to one hundred and sixty

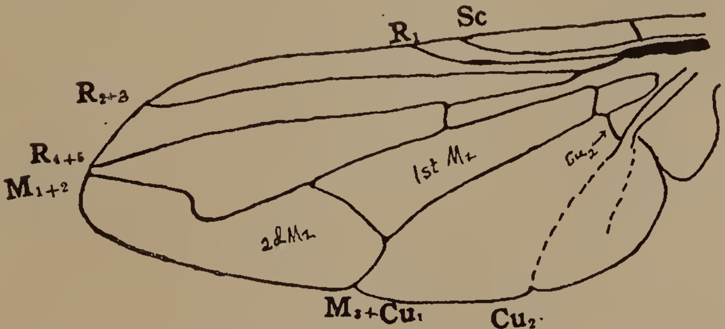

FIG. 566. — Wing of the housefly.

eggs; the larvæ become full-grown in from five to seven days, having molted twice; the pupa state lasts from five to seven days. There may be in the warm season a generation each month. Since the fly picks up the germs of typhoid fever in the filthy places where it breeds and carries them to our kitchens and dining rooms, it is a dangerous fly and should be destroyed wherever possible. The fifth longitudinal vein (M_{1+2}) turns abruptly upward at the end (Fig. 566).

The stable-fly, *Stomŏxys călcitrans.* — This species resembles the housefly in appearance, but it is a trifle larger and has its mouth-parts fitted for piercing and for sucking blood. It annoys cattle greatly; and before storms and in the autumn it enters our dwellings and attacks us. The popular belief that the housefly bites more viciously just before a rain is due to invasions of this species at such times. The mouth-parts of the true housefly are not fitted for piercing.

The horn-fly, *Hæmatōbia ĭrritans.* — This is an exceedingly annoying pest of horned cattle. It resembles the housefly in appearance, but is less than half as large. These flies cluster in great numbers around the base of the horns; they also settle upon the back. The larvæ live in fresh cow-manure.

The tsetse-fly, *Glossīna morsĭtans.* — This species, which is closely allied to the stable-fly, is widely distributed in Africa and is the carrier of the blood parasite that causes the disease of cattle known as "nagana." The closely related species, *Glossīna palpălis*, carries the blood parasite which causes the sleeping sickness of man.

THE PUPIPARA

There are several families of related flies in some of which, at least, the larvæ attain their full growth within the body of the female fly and within a few hours after the larvæ are born they change to pupæ. It was formerly supposed that the young were born as pupæ hence the name, Pupipara.

The adult flies are parasitic and live like lice on the bodies of birds and mammals. Two species are parasites of the honey-bee. The wings are well developed in some forms while in others they are vestigial or wanting.

Family HIPPOBOSCIDÆ

The Louse-flies

The louse-flies are very abnormal flies that, in the adult state, live like lice, parasitically, upon the bodies of birds and mammals. Some species are winged, others are wingless, and still others are winged for a time and then lose their wings.

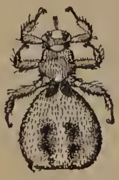
FIG. 567.

The sheep-tick, *Melŏphagus ovīnus.* — This well-known pest of sheep is the most common member of the Hippoboscidæ found in this country. It is wingless and its halteres are vestigial (Fig. 567). It is about ¼ of an inch in length, of a reddish or gray-brown color, and with the entire body covered with long bristly hairs. This pest is often very injurious, especially to lambs after shearing time, as it tends to migrate from the old sheep to the lambs at this period.

There is a yellowish winged species, *Lynchia americana*, which is rather common on owls, and on the ruffed grouse.

Family BRAULIDÆ

The Bee-lice

This family includes only a single genus, *Braula*, of which there is only one well-known species, *Braula cæca*. This is a minute insect, $\frac{1}{16}$ of an inch in length, which is parasitic upon the honey-bee (Fig. 568).

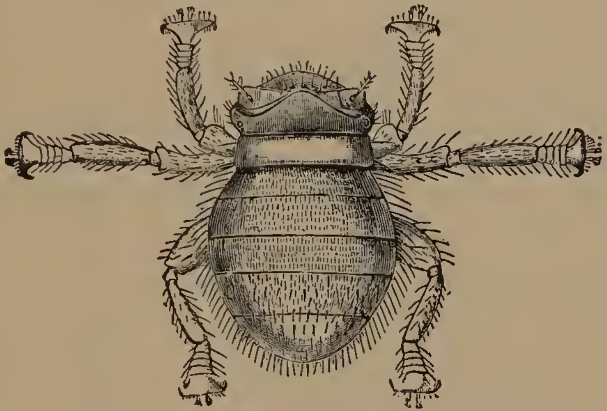

FIG. 568. — *Braula cæca*. (From Sharp after Meinert.)

It is found clinging to the thorax of queens and drones. It is wingless and also lacks halteres; the head is large; the ocelli are wanting; the eyes are vestigial; the legs are comparatively short; and the last segment of the tarsi is furnished with a pair of comb-like appendages.

The bee-louse lays eggs and therefore does not seem to be a member of the Pupipara.

FAMILIES OF DIPTERA NOT DISCUSSED

The order, Diptera, contains a large number of families the members of which are not likely to come within the field of the general student of entomology. The following list includes those families of flies which have not been discussed in this work but of which the student can find an account in "An Introduction to Entomology" by J. H. Comstock.

Thaumaleidæ
Xylomyidæ
Xylophagidæ
Coenomyidæ
Nemestrinidæ
Apioceridæ
Conopidæ
Clusiidæ
Helomyzidæ
Borboridæ
Phycodromidæ
Sciomyzidæ
Sapromyzidæ
Lonchaeidæ
Tanypezidæ
Micropezidæ
Sepsidæ
Diopsidæ
Canaceidæ
Asteiidæ
Geomyzidæ
Milichiidæ
Ochthiphilidæ
Streblidæ

CHAPTER XXVI

ORDER SIPHONAPTERA *

The Fleas

The members of this order are small, wingless insects, in which the body is laterally compressed, so that the transverse diameter is small, the vertical one great. The mouth-parts are formed for piercing and sucking. The metamorphosis is complete.

These tiny tormentors are best known to us in the adult state; for it is only the adults that annoy us and our household pets. The larvæ and pupæ are rarely observed except by students who search for them.

The body of the adult is oval and greatly compressed, which allows the insect to glide through the narrow spaces between the hairs of its host. The integument is smooth, quite hard, and armed with bristles, which are arranged with great regularity (Fig. 569) and thus afford good characters for distinguishing the different species. The smoothness and firmness of the body make it easy for the insect to escape when caught between the fingers of man or the teeth of lower animals. When once out of the clutch of an enemy it quickly leaps away.

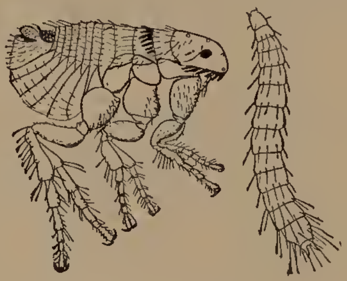

FIG. 569. — The dog-flea and its larva.

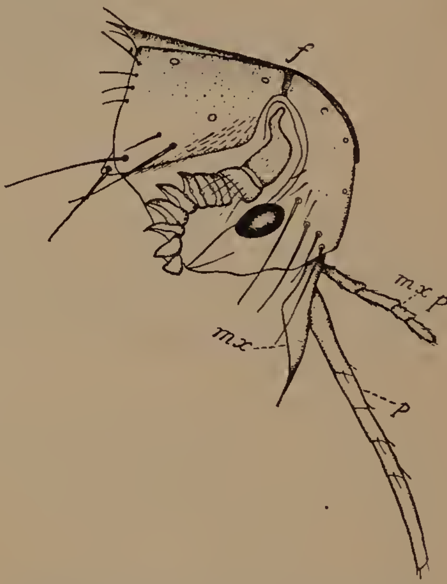

FIG. 570. — Head of a flea, *Ceratophyllus multispinosus*: *f*, falax; *mx*, maxilla; *mx.p*, maxillary palpi; *p*, proboscis. (After Baker.)

The head is broadly joined to the thorax. There are no compound eyes; but on each side of the head there is usually an unfaceted eye; these, however, are sometimes wanting. Each antenna lies in a groove somewhat behind and above the eye (Fig. 570). The antennæ are three-segmented; the third segment, which is called the flagellum, may also be divided into several divisions or false-segments. The legs of fleas are long, strong, and fitted for leaping.

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* Siphonaptera: *siphon* (σίφων) a tube; *apteros* (ἄπτερος) without wings.

The mouth-parts are formed for piercing and sucking. When seen without dissection, the following parts are apparent; the maxillæ, which are triangular plates; the maxillary palpi, which are long and four-jointed; and the proboscis (Fig. 570).

The eggs of fleas are scattered about the floors of dwellings and in the sleeping-places of infested animals. The larvæ are slender, worm-like creatures, with a distinct head and without legs. (Fig. 569.) They have biting mouth-parts, and feed upon the decaying particles of animal and vegetable matter always to be found in the dirt in which they live. When full-grown the larva spins a cocoon within which the pupa state is passed.

Fleas are parasitic only in the adult state. Some species infest birds, but by far the larger number prey upon mammals, and most mammals are subject to the attacks of these parasites. Although the different species of fleas infest different hosts they are not so restricted in their host relations as are many parasites, and may pass from their normal host to another species; for example, both the dog-flea and the cat-flea frequently attack man.

Formerly fleas were regarded as merely annoying pests of man and his pets; but it has been found that fleas are the carriers of bubonic plague; this fact has greatly increased the interest in these insects.

Except where bubonic plague is present the bites of fleas are not likely to cause serious results, although they may be very annoying. The irritation caused by them can be relieved by the use of some cooling application as menthol, camphor, or carbolated vaseline. Scratching the bites should be avoided as that aggravates the inflammation.

There are hundreds of species of fleas in the world but the following forms are among those best known because they are most intimately associated with man:

The cat-flea, *Ctenocĕphalus felis.* — This is the species that is most often found in our dwellings in the East and in the South, and the one that most often attacks man in these regions. This species infests dogs as well as cats. Its head and thorax bear rows of short, stout, dark spines known as *ctenidia.*

The dog-flea, *Ctenocĕphalus canis.* — This species is closely allied to the cat-flea. It infests dog, cat, and man. The head and thorax bear ctenidia.

The human flea, *Pulex irrītans.* — On the Pacific Coast this is the species that is most often found in houses attacking man. It is easily distinguished from the two preceding species by the fact that its head and thorax lack ctenidia. Man is its natural host; but it will infest various other animals temporarily.

The Indian rat-flea, *Xenopsўlla chēopis.* — Among the various species that are supposed to transmit the bubonic plague, this cosmopolitan species is regarded as one of the more important. It resembles the human flea in lacking ctenidia.

The sticktight flea, *Echidnŏphaga gallinācea.* — This is a very serious pest of poultry especially in the southern and southwestern portions of the United States. It is a small, dark brown species, which is often found in dense masses attached to its host; heads of chickens are often covered with dark patches of these fleas. While this species is chiefly a pest of poultry, it is often found in dense masses on the ears of dogs and cats.

The chigoe (chig′ō) or jigger, *Tŭnga pĕnetrans.* — This is a small flea found in the West Indies, Mexico, Central and South America, and in tropical Africa. It has been reported from Florida but it is not known to be established in the United States. The males and the unimpregnated females live in dry, sandy soil; they are only about one millimeter in length, and behave in the ordinary manner of fleas, feeding on the blood of man and many other animals, domestic and wild, and even birds. When impregnated, the female burrows into the skin of her host. Soon after this the abdomen becomes distended with eggs and acquires the size of a small pea. This species often causes serious injury to man by burrowing beneath the skin of the foot, causing the formation of a sore, which may become infected with bacteria, and cause the loss of a toe or a leg.

In the southern United States the names chigoe and jigger are improperly applied to the harvest-mites, which are the immature six-legged forms of various mites that attach themselves like ticks to the skin and become gorged with blood.

CHAPTER XXVII

ORDER HYMENOPTERA *

Bees, Wasps, Ants, and others

The winged members of this order have four wings; these are membranous and have the wing-venation more or less reduced. The hind wings are smaller than the fore wings. The mouth-parts are formed for chewing or for both chewing and sucking. The abdomen in the females is usually furnished with a sting, piercer, or saw. The metamorphosis is complete.

The Hymenoptera is a very large order, including a vast number of species. The bees, wasps, and ants are among the better-known members of it; but in addition to these it includes a large number of less familiar forms. Many of these are minute parasites of other insects; others cause the growth of galls on plants; and still others, in their larval state, feed on the foliage of plants or are borers in the stems of bushy or herbaceous plants or in the limbs and trunks of trees.

The members of this order are chiefly of small or moderate size, and many of them abound wherever flowers bloom. From very early times some of them have been favorites with students of the habits of animals, for among them we find wonderful developments of instinctive powers. Many volumes have been written regarding their ways, and much remains to be discovered, even concerning our most common species.

The membranous nature of the wings, which suggested the name of the order, is not a distinctive characteristic, for it is possessed by the wings of many other insects.

The two pairs of wings are similar in texture. The wings of each side are held together by a row of hooks, the *hămuli*, on the front margin of the hind wing (Fig. 571); these hooks fasten to a fold in the hind margin of the front wing, so that the two wings present a continuous surface. The hind wings are smaller than the fore wings and have a more reduced venation. Some forms are apterous.

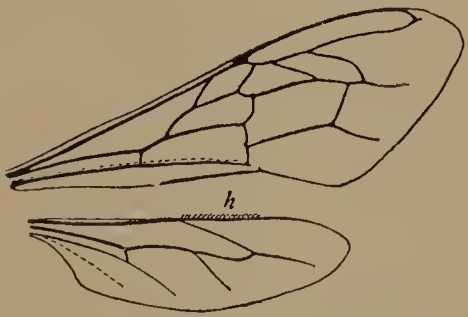

FIG. 571. — Wings of bee showing hamuli, *h*.

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* Hymenŏptera: *Hymen* (ὑμήν), membrane; pteron (πτερόν), wing.

This is one of the orders in which in the specialization of the wings the wing-venation is reduced. In the more generalized members of the order this reduction of the wing-venation is slight, but in the more specialized forms it is extreme.

Figures 572 and 573 represent what may be regarded as a typical hymenopterous wing; in the former the veins are lettered, in the latter, the cells.

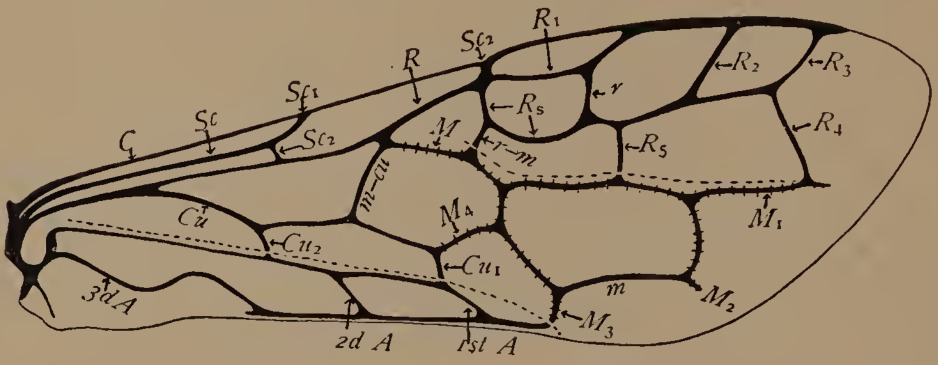

FIG. 572. — The veins of a typical hymenopterous wing.

The cells marked *m*, *m*, *m*, in Figure 573 are termed the *marginal cells;* and those marked *sm*, *sm*, *sm*, *sm*, the *submarginal cells;* the three cells, M_4, 1st M_2, and M_3 are termed the *discal cells.*

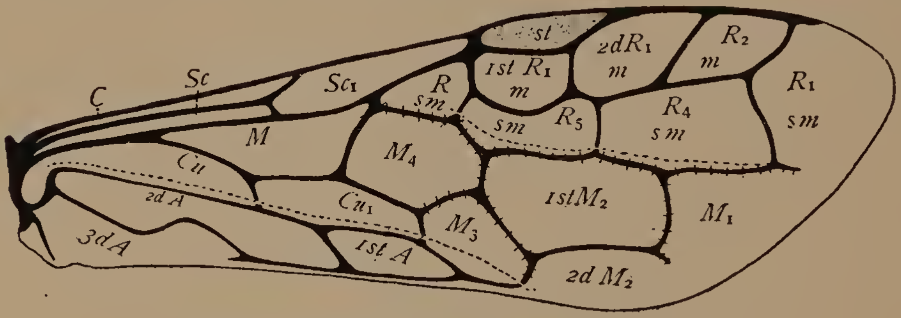

FIG. 573. — The cells of a typical hymenopterous wing.

The working out of the various ways in which the wing-venation has been reduced in the more specialized families is an exceedingly difficult problem, one that is beyond the scope of this book.

The mouth-parts are formed for chewing in all Hymenoptera, and in the more specialized members of the order they are fitted for both chewing and for sucking or lapping liquid food. In the sawflies, for example, the mouth-parts resemble quite closely the orthopterous type, while in the bees they differ markedly from this type; and intermediate forms exhibit intermediate degrees of modification of the mouth-parts.

In the long-tongued bees the labrum and mandibles retain the form characteristic of chewing insects and the mandibles function as organs for crushing or cutting; but the labium and maxillæ are elongated; the maxillæ form a sheath to the labium; the three organs thus constituting a suctorial apparatus (Fig. 574). In this figure the maxillæ are represented separated from the labium.

The legs of the Hymenoptera present characters that are much used in the classification of these insects. Among the more striking of these are the following; the trochanter may consist of two segments (Fig. 64, B) or of only one; the metatarsus of the hind legs is greatly enlarged in bees (Fig. 64, C); and in several families the fore legs are fitted with an organ which is used in cleaning the antennæ, the *antenna cleaner* or *strigilis*. This consists of a curved, comb-like, movable spur on the distal end of the fore tibia (Fig. 575) and opposite this, on the base of the metatarsus, a concavity fringed with hairs. In cleaning an antenna it is drawn through the space between these two parts of the strigilis.

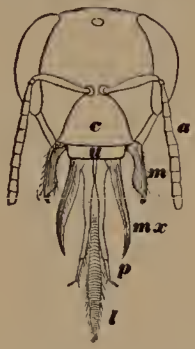

Fig. 574. — Head of a honey-bee: *a*, antenna; *c*, clypeus; *u*, labrum; *m*, mandible; *mx*, maxilla; *p*, labial palpus; *l*, labium.

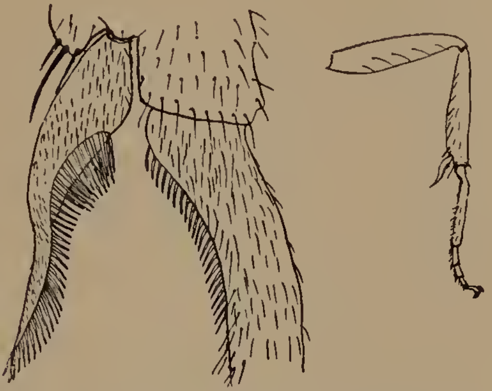

Fig. 575. — Leg of an ant, and strigilis enlarged. (From A. B. Comstock, Handbook of Nature Study.)

In the Hymenoptera the metamorphosis is complete. The larvæ of the first suborder are caterpillar-like in form and are furnished with thoracic legs and usually with abdominal prolegs; but in some, mostly borers or internal feeders, the prolegs are wanting. In all the forms of the third suborder the larvæ are maggot-like in form and have no legs. The pupæ are of the exarate type, that is, the legs and wings are free, as in the Coleoptera. With many species the larva, before changing to a pupa, spins a cocoon about its body. With some this cocoon is composed of comparatively loose silk, and resembles somewhat the cocoon of a moth. In others the cocoon is of a dense parchment-like texture, and in still others it resembles a very delicate foil.

Parthenogenesis. — The production of young by females that have not mated is known to occur in members of several families of this order. In some species the young thus produced are all males; in others they are all females; and in still others both males and females are developed from unfertilized eggs.

Polyembryony. — In several genera of minute parasitic Hymenoptera the number of young produced is not dependent upon the number of eggs laid, for with these insects many embryos are developed from a single egg. This type of development is termed polyembryony.

THE CLASSIFICATION OF THE HYMENOPTERA

The sequence of the families and arrangement of the groups adopted in this chapter are after Messrs. J. C. Bradley, S. A. Rohwer, and J.

Bequaert. Since there is lack of agreement regarding the names of genera and families we have preferred to retain the older forms.

In order for the student to use the keys to advantage certain terms need to be defined.

The propodeum. — The first abdominal segment when it forms a part of the alitrunk or wing-bearing region of the body.

The posterior lobes of the pronotum. — A distinctly differentiated rounded lobe, on each side covering the spiracle, which forms the lateral extension of the pronotum of Sphecoidea.

The prepectus. — An area along the cephalic margin of the episternum of the mesothorax which in some Hymenoptera is separated by a suture-like furrow.

The gaster. — The swollen portion of the abdomen behind the pedicel in the suborder Clistogastra.

The pygĭdial area. — In many of the aculeate or stinging Hymenoptera there is an area on the pygidium which is bounded on each side by a carina, the two carinæ meeting posteriorly on the middle line of the segment; this area is known as the *pygidial area.*

The ānal lobe. — The portion of the anal area of the hind wing which is cut off by the axillary excision (Fig. 576).

The axillary excision. — A notch in the inner margin of the hind wing near its base (Fig. 576).

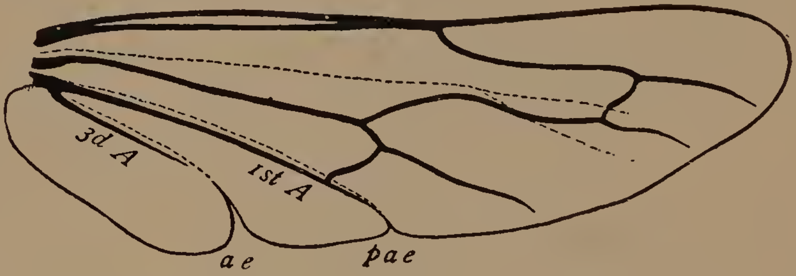

FIG. 576. — Hind wing of *Elis* showing anal lobe; axillary excision, *æ*; preaxillary excision, *pæ*.

The preaxillary excision. — A notch in the inner margin of the hind wing distad of the axillary excision (Fig. 576).

The preanal lobe. — That portion of the anal area of the hind wings that lies between the axillary excision and the preaxillary excision constitutes the preanal lobe.

The pygidium. — The tergite or dorsal wall of the last segment of the abdomen.

The hypopygium. — The sternite or ventral wall of the last segment of the abdomen.

The tegula. — The scale-like plate overlapping the base of each front wing.

The corbicula. — A smooth area on the outer surface of the tibia of the hind legs margined on each side by a fringe of long curved hairs.

KEY TO THE SUBORDERS OF THE HYMENOPTERA

A. Base of the abdomen not slender but broadly joined to the thorax.
  B. Antennæ inserted between the eyes above the base of the clypeus with the bases of the antennæ exposed; front wings with the transverse part of vein M_2 present or if wanting (*Hylotoma*) then vein R_4 is present in the hind wings

which therefore have a closed submarginal cell; ovipositor either saw-like or a sturdy borer, never thread-like or capable of being coiled within the body. p. 338 .... CHALASTOGASTRA

BB. Antennæ inserted below the eyes immediately above the mandibles under a transverse ridge, their bases concealed; front wings with the transverse part of vein M_2 wanting; vein R_4 in the hind wings wanting, therefore no closed submarginal cells; ovipositor thread-like and coiled within the mesothorax. p. 343 .... IDIOGASTRA

AA. Base of the abdomen constricted into a narrow pedicel. p. 345.... CLISTOGASTRA

TABLE FOR DETERMINING THE FAMILIES OF THE CHALASTOGASTRA

A. Front wings with three marginal cells, both vein R and R_2 being present; the basal segments of the flagellum are consolidated, thus forming what appears to be a very long third segment, and the remaining segments are small. .... *Xyelidæ**

AA. Front wings with the free part of vein R_2 always wanting; antennæ with three or more segments, third segment never as long as all the following segments together; if the third segment be long, antennæ, consisting of only three segments.

B. Front wings with subcosta present as a distinct longitudinal vein. p. 339 .... PAMPHILIIDÆ

BB. Front wings with subcosta absent; rarely it is present as a pale, very indistinct line, closely appressed to vein R + M, or vein Sc_1 may be present as a transverse vein.

C. Radial cross-vein (*r*) of the front wings received by the 2nd submarginal cell (R_5) or if it is absent or the 2nd and 3rd submarginal cells united (R_4 united with R_5), then the anterior tibiæ have a single apical spur.

D. Front wings with the cross-vein *m-cu* subequal in length to the first section of the free part of media.

E. Vein Sc_1 absent in the front wings; the last abdominal segment bears a more or less horn-like prolongation; maxillary palpi one-segmented; labial palpi two- or three-segmented, the last segment enlarged and bearing a large sensory cup, the first segment not elongate. p. 339 .... SIRICIDÆ

EE. Vein Sc_1 present; last abdominal segment without horn-like prolongation; maxillary palpi four-segmented; labial palpi three-segmented, the last without a sense-cup, the first elongate. *Xiphydriidæ*

DD. Front wings with the cross-vein *m-cu* joined to vein M at or near its separation from vein R. p. 340 .... CEPHIDÆ

CC. Radial cross-vein (*r*) of the front wings received by the 3rd or 4th submarginal cell (cell R_4 or R_3) or wanting; anterior tibiæ always with two apical spurs.

D. Abdomen with distinct pleural sclerites; bearing the spiracles, antennæ clavate. p. 341 .... CIMBICIDÆ

DD. Abdomen without separate pleural sclerites; antennæ not clavate in North American forms. p. 342 .... TENTHREDINIDÆ

TABLE OF FAMILIES OF THE CLISTOGASTRA †

A. With well-developed wings.

B. Hind wings without an anal lobe.‡

C. No erect scale or node between the gaster and the propodeum.

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* The families in italics are not discussed in the text.

† This table of families of the North American Clistogastra is compiled from a table of the families of the Clistogastra of the world prepared by Professor J. Chester Bradley.

‡ In the hind wings of the insects belonging under this category neither the second anal furrow nor the axillary excision is present, but there is sometimes present a weak preaxillary excision, more rarely (some genera of Braconidæ) a pronounced notch, but never forming a deep slit. See also footnote on page 335.

D. The costal cell of the fore wings eliminated by the coalescence of the costal and subcostal veins, except in the case of two or three rare genera. The venter is membranous and has in dried specimens a longitudinal fold.

E. The transverse part of vein M$_2$ of the fore wings wanting, causing the union of cells M$_1$ and 1st M$_2$ (Fig. 583).

F. The abdomen not very long and slender and strongly compressed. p. 346 .... BRACONIDÆ

FF. The abdomen very long, slender, and strongly compressed. (The genus *Pharsalia*) p. 347 .... ICHNEUMONIDÆ

EE. Cells M$_1$ and 1st M$_2$ separated by the transverse part of vein M$_2$ (Fig. 587). p. 347 .... ICHNEUMONIDÆ

DD. The costal cell of the fore wings present. The venter chitinized.

E. Abdomen borne on the dorsal surface of the propodeum far above the hind coxæ .... *Aulacidæ* and *Gasteruptionidæ* *

EE. Abdomen borne between the hind coxæ, or on the end of the propodeum slightly above them.

F. The transverse part of vein M present and situated close to the stigma.

G. Antennæ in both sexes of more than fifteen segments; trochanters clearly two-segmented .... *Trigonalidæ*, *Stephanidæ*

GG. Antennæ of thirteen segments in the male and twelve in the female; trochanters one-segmented.

H. Pronotum without posterior lobes its lateral extensions reaching the tegulæ.

I. Cell M$_4$ of the fore wings shorter than cell Cu + Cu$_1$ or absent (Mutillinæ). p. 356 .... MUTILLIDÆ

II. Cell M$_4$ of the fore wings present and longer than cell Cu + Cu$_1$ (Fig. 607). (Vespinæ) p. 364 .... VESPIDÆ

HH. Pronotum with posterior lobes terminating at a distance from the tegulæ. (This distance is short in the Ampulicinæ.) .... *Ampulicidæ* and Some Bees

FF. The transverse part of vein M situated about two-thirds of the way from the wing base to the end of the costal cell (C + Sc$_1$) or wanting.

G. Wings not longitudinally plaited in repose. Ovipositor not carried along the mid-dorsal line.

H. The pronotum laterally reaching the tegulæ. No prepectus present.

I. Hind metatarsi one-fourth the length of the following segment. Large insects; the abdomen of the female filiform and several times the length of the head and thorax together; that of the male long and clavate. p. 348 .... PELECINIDÆ

II. Hind metatarsi at least as long as the following segment.

J. Mandibles in a reversed position, their apices directed outwardly, away from the mouth-opening .... *Vanhorniidæ*

JJ. Mandibles in a normal position.

K. Cells Cu + Cu$_1$ and M$_3$ of the fore wings fully enclosed and separated from each other by perfect veins. .... *Heloridæ* and *Roproniidæ*

KK. Cells Cu + Cu$_1$ and M$_3$ partly enclosed by brown lines, or altogether wanting. Claws not pectinate.

L. Abdomen sharply margined by a carina along the sides; antennæ arising near the clypeus. .... *Platygasteridæ* and *Scelionidæ*

LL. Abdomen immargined laterally (acute in Telenominæ but without a carina).

M. Fore wings with a distinct stigma.

N. A closed, usually very short, marginal cell (2d R$_1$ + R$_2$) present. Antennæ of thirteen segments. Abdomen with a short cylindrical petiole, the second segment much longer and larger than the others. p. 348 .... PROCTOTRUPIDÆ

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* The families in italics are not discussed in the text.

NN. No closed marginal cell (2d $R_1 + R_2$) but the basal part of the marginal vein (vein C) often present in the fore wings.........*Ceraphronidæ* and *Belytidæ*

MM. Fore wings without a distinct stigma.

N. Costal cell ($C + Sc_1$) either closed along the margin or if open very narrow; the marginal cell (2d $R_1 + R_2$) if present narrowly triangular, its proximal margin a straight line: Abdomen not compressed nor dorsally keeled. Hypopygium of the female not divided, but closely applied to the pygidium, the ovipositor issuing from between them at the tip of the abdomen. ....*Belytidæ*, *Scelionidæ* and *Ceraphronidæ*

NN. Costal cell ($C + Sc_1$) open along the costal margin and abnormally wide. The marginal cell (2d $R_1 + R_2$) present; often closed; often open along the costal margin, sometimes at tip; it is always four-sided, acute at apex and at its base. Abdomen more or less strongly compressed and with a mid-dorsal keel, if rarely but little compressed and without a keel, it is more or less swollen dorsally. Hypopygium of the female divided, the ovipositor issuing from the cleft thus formed, anterior to the apex of the abdomen. p. 349..........CYNIPIDÆ

HH. The pronotum not reaching the tegulæ, separated therefrom by a chitinized sclerite, the prepectus. Antennæ elbowed, never more than thirteen-segmented. Fore wings with a short narrow costal cell open along its anterior margin (Fig. 598); its apex remote from the stigmal vein (Fig. 598, *d*); a more or less elongate marginal vein (Fig. 598, *b*); postmarginal and a stigmal spur (Fig. 598, *d*). An occasional trace of the transverse part of vein M is the only additional vein present, there being never any closed cells. p. 352........................CHALCIDIDÆ

GG. Wings longitudinally plaited in repose, ovipositor carried along the mid-dorsal line. Pronotum reaching the tegulæ, the prepectus not being distinctly set off. (*Leucospis*.) p. 352......CHALCIDIDÆ

CC. An erect scale or one or two nodes between the propodeum and the gaster. p. 357..FORMICIDÆ

BB. Hind wings with an anal lobe.* If there are any closed cells in the hind wings the antennæ are thirteen-segmented in the male, twelve- in the female, except in a few instances where the number is reduced by fusion, but then the apical segments always form a club, or are abruptly recurved or otherwise strikingly modified, (except that in some species of *Crabro* both sexes have twelve-segmented, otherwise normal antennæ).

C. Hind wings without closed cells. Antennal segments never thirteen in the male and twelve in the female, nor are the apical segments in the male formed into a distinct club or otherwise peculiarly modified. Venation reduced.

D. Abdomen attached to the dorsal surface of the propodeum.....*Evaniidæ*

DD. Abdomen attached normally, at the apex of the propodeum between or slightly above the hind coxæ.

E. Antennæ composed of ten segments, or if of thirteen in the female (*Ampulicomorpha*) then the pronotum is elongate and has a median longitudinal sulcus. Antennæ inserted close to the clypeus. Fore tarsi of the female usually chelate. p. 370..*Embolemidæ* and DRYINIDÆ

EE. Antennæ usually composed of thirteen segments, more rarely of twelve or eleven segments, or multiarticulate.

F. Abdomen with six exposed segments or less. Fore wings always with

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* If there is a very deep or slit-like incision on the margin of the hind wing, the insect is certain to come under this heading. There are some genera of Sphecidæ in which the axillary excision or both axillary and preaxillary excisions are reduced to small and inconspicuous notches, close to one another, and in some cases the axillary excision is altogether lacking. But in all such cases the second anal furrow is distinct. In all insects falling under grouping B this furrow is wanting.

cells M and Cu + Cu_1 closed. Ovipositor an extensile jointed tube. Abdomen with from three to six exposed segments. Brilliantly metallic. p. 356. . . . . *Cleptidæ* and CHRYSIDIDÆ

FF. Abdomen with eight exposed segments, the petiolar segment short and scarcely perceptible. Ovipositor a sting. . . . . *Bethylidæ*

CC. Hind wings with at least a closed median cell (cell M). Males with thirteen, females with twelve antennal segments, except in rare instances, where they have been reduced slightly below that number in the males, in which case they usually either end in a jointed club or the last segments are recurved or hooked or otherwise modified. Venation usually well preserved.

D. The pronotum extending laterally directly to the tegulæ, where its lateral prolongations do not terminate in the form of a rounded "posterior lobe" covering the spiracles.

E. Cell M_4 of the fore wings longer than cell Cu + Cu_1. Lateral prolongations of pronotum forming a posterior angle which lies above the tegulæ. Wings usually longitudinally plaited. p. 364. . . . . VESPIDÆ

EE. Cell M_4 of the fore wings shorter than cell Cu + Cu_1 or absent. Lateral prolongations of pronotum bluntly rounded, not lying dorsad of the tegulæ. Wings never longitudinally plaited.

F. Mesopleura divided by a transverse suture into an upper and lower plate. First and second abdominal sternites imbricate. Coxæ very large and long; the legs long and usually distinctly spinose. p. 355 . . . . POMPILIDÆ

FF. Mesopleura not divided by a transverse suture. Coxæ and legs not unusually long.

G. First abdominal segment united by a ball and socket joint to the second, and itself forming an almost completely separated "scale" or "node." Hypopygium of male unciform. Females winged; a worker caste present. (Some more primitive genera of ants.) p. 357. . . . . FORMICIDÆ

GG. First abdominal sternite attached to the second by a suturiform articulation or more or less imbricate, the first segment not forming a "scale" or "node" between the propodeum and the gaster.*

H. Mesosternum not forming with the metasternum a continuous plate overlying the bases of the hind and middle coxæ. Axillary excision of the hind wings in normal position, apex of male abdomen without three retractile spurs between the last tergite and its sternite.

I. Vein $M_4 + Cu_1$ of the fore wings opposite vein *m-cu* or nearly so. Second and third tarsal segments of the female not dilated.

J. Mesosternum with two laminæ which overlie the bases of the middle coxæ.

K. Little or no constriction between the first and second abdominal sternites, which are almost or somewhat imbricate. Hypopygium of male not unciform. Both sexes winged. . . . . *Anthoboscidæ*

KK. First and second abdominal sternites separated by a strong and distinct suturiform articulation and either the hypopygium of the male is unciform, or the females are wingless and carried about by the males in mating.

L. Hypopygium of the male not unciform; but sometimes it is tridentate at apex. Females apterous and carried about by the males in mating. First submarginal cell usually divided by a weak vein (base of the radial sector). . . . . *Thynnidæ*

LL. Hypopygium of male unciform, known American females winged. First submarginal cell not divided (base of R_s wanting).

M. Diurnal insects with normal eyes and ocelli. Females winged. (Tiphiinæ). p. 356. . . . . TIPHIIDÆ

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* Some genera of Mutillidæ in which the first or first and second abdominal segments are more or less nodose may be recognized as falling in this category by the unciform hypopygium of the males, the apterous females, and the absence of a neuter caste.

MM. Nocturnal insects with enlarged eyes and ocelli. The marginal cell (2d $R_1 + R_2$) removed from the apex of the wing by several times its length. Females unknown but presumably apterous. (Brachycistinæ). p. 356........................MUTILLIDÆ

JJ. Mesosternum simple or with two minute erect teeth between the bases of the coxæ.

K. Marginal cell (2d $R_1 + R_2$) removed by less than its length from the wing apex; the fourth submarginal cell (R_3) not traversed by an adventitious vein. Abdomen never petiolate.

L. No constrictions between the abdominal segments (except between the first and the second), all tergites and all but the first and second sternites loosely imbricated plates. Both sexes winged. Mesosternum unarmed, upper surface of hind coxæ simple. ....*Sapygidæ*

LL. Strong constrictions between each of the abdominal segments, the tergites and sternites all heavily chitinized and not loosely imbricate; the last tergite modified and hood-like. Female apterous. Upper surface of the hind coxæ, at least in the male, with a lamella. (Methocinæ and Myrmosinæ). p. 356.........TIPHIIDÆ

KK. Marginal cell (2d $R_1 + R_2$) removed by two or more times its length from the apex of the wing; cell R_3 when present usually traversed by a longitudinal adventitious vein. Often nocturnal insects with large eyes and ocelli. Females apterous. (Several subfamilies.) p. 356.
....MUTILLIDÆ

II. Vein $M_4 + Cu_1$ of the fore wings more than two-thirds its length apicad of vein *m-cu*. Second and third tarsal segments of the female dilated, deeply excised, and filled with membrane between the lobes. Nocturnal insects with very large eyes and ocelli. Petiole long and slender. Hypopygium unarmed.....*Rhopalosomidæ*

HH. Mesosternum and metasternum together forming a continuous plate overlying the bases of the hind and middle coxæ, separated from each other by a transverse suture. Axillary excision of the hind wings almost opposite the apex of cell $M_3 + Cu_1 + Cu$. Abdomen of male with three spines. p. 357........SCOLIIDÆ

DD. Pronotum terminating behind laterally in the form of two clearly differentiated rounded "posterior lobes," covering the spiracles. These lobes reach the tegulæ in North American forms only in the extremely rare genus *Dolichurus*.

E. Posterior metatarsus not dilated. No plumose hairs. Females without pollen-collecting apparatus, but often with a comb on the anterior tarsi. Maxillæ rarely elongate; if so, either the ocelli are distorted, or the abdomen has a petiole composed only of the first sternite.

F. Abdomen of the male with only three or four exposed tergites. Last sternite of the female, enclosing the sting..............*Ampulicidæ*

FF. Abdomen of the male with seven exposed tergites. Sting not enclosed by the hypopygium. p. 370 ....SPHECIDÆ

EE. Posterior metatarsi elongate and dilated. Some of the hairs, especially of the thorax, plumose. A pollen-collecting brush or a corbicula present in the majority of females. Maxillæ usually with either the stipes or the lacinia elongate; the latter often very long and covering the tongue; the ocelli never distorted; the abdomen rarely petiolate, and never with a petiole composed only of the first sternite.

F. Hind tibiæ with apical spurs. If the marginal cell (2d $R_1 + R_2$) is long and slender, reaching nearly to the wing apex, the anal lobe is short and fully separated. Cell M_4 usually as large as cell 1st M_2.

G. Females without a corbicula. First submarginal cell (R + 1st R_1) rarely divided (by the base of R_s) in which case there is a large anal lobe present. In case the marginal cell (2d $R_1 + R_2$) is longer than the three submarginals, taken together, there is usually a well-marked anal lobe in the hind wings.

H. Wings with two submarginal cells (very rarely less).

I. Tongue short and the basal segments of the labial palpi not sheath-like; or the labrum is large and free and uncovered. Females without a ventral pollen-collecting brush; often with a pygidial area.

J. Tongue short, its apex bifid; labial palpi normal. Female only rarely with a pygidial area. Mesepisternal suture present. Labrum hidden (Prosopinæ)............*Prosopidæ*

JJ. Tongue long or short, but its apex acute; the labial palpi normal or their basal segments sheath-like. Mesepisternal suture wanting. (Many.) p. 375.............ANDRENIDÆ

II. Tongue elongate, the basal segments of the labial palpi sheath-like. Labrum not large and free, usually entirely covered by the clypeus, or if somewhat visible, then strongly inflexed. Females without a pygidial area; those of the non-parasitic species with a ventral pollen-collecting brush. p. 377 ....MEGACHILIDÆ

HH. Wings with three submarginal cells. Females without a ventral pollen-collecting brush; often with a pygidial area.

I. Tongue short, its apex bifid. Labial palpi normal. Females rarely with a pygidial area. Mesepisternal furrow present. ....*Prosopidæ*

II. Tongue long or short, but its apex acute. The labial palpi normal, or the basal segments sheath-like. Mesepisternal suture rarely present. (Most.) p. 375.............ANDRENIDÆ

GG. Females and workers with corbiculæ (except *Psithyrus*). First submarginal cell divided by a transverse, hair-like chitinized streak (base of R_s), rarely indistinct. Marginal cell (2d $R_1 + R_2$) rather long and pointed or appendiculate, usually as long as the three submarginal cells taken together, and extending far beyond the apex of the third (R_4). Malar space large and distinct. Hind wings stalked, the anal lobe absent. Tongue very long; the two basal segments of the labial palpi and the laciniæ elongate, and forming a sheath. Social insects with normally a worker caste (except in *Psithyrus*). p. 379.........................BOMBIDÆ

FF. Hind tibiæ without apical spurs. Social insects with a worker caste. Workers with corbiculæ; females without functionally developed ones. Marginal cell (2d $R_1 + R_2$) long and slender reaching nearly to the wing apex. Anal lobe of the hind wing long and scarcely separated. Cell 1st M_2 much larger than cell M_4. Eyes hairy. p. 381......APIDÆ

AA. Without wings.

B. A "scale" or "node" between the propodeum and the gaster. p. 357. FORMICIDÆ

BB. Without a scale or node between propodeum and gaster.

C. Females; sting well developed. p. 356...........TIPHIIDÆ and MUTILLIDÆ

CC. Males, or, if females, the ovipositor does not form a sting. Occasional species or genera of several families of the parasitic Hymenoptera. pp. 345 to 355.

Suborder CHALASTOGASTRA *

The Sawflies

This suborder includes the more generalized members of the Hymenoptera, those in which the form of the body is less modified and the venation of the wings less reduced than is the case with other members of the order.

The basal segments of the abdomen are similar in form and the abdomen is broadly joined to the thorax as in the more generalized orders of insects. The first abdominal segment is not closely anchylosed to the thorax, forming a propodeum, as is the case in the Clistogastra, and its tergum is usually longitudinally divided on its middle line.

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* Chalastogăstra; *chalastos* (χαλαστός), loose; *gastros* (γαστρός), the belly.

The ovipositor of the females is well developed and complicated in structure. It is fitted for making incisions in the leaves or stems of plants and is more or less saw-like in form.

The larvæ of the Chalastogastra are all plant-feeders. With the exception of those that are leaf-miners they are caterpillar-like in form. The prolegs, however, are not provided with hooks as are those of caterpillars.

A striking feature of the larvæ of this suborder is the possession of a pair of ocelli, one on each side, which in their position and in their structure agree with the ocelli of adult insects, that is, they are primary ocelli. This characteristic distinguishes these larvæ from the larvæ of Lepidoptera.

The members of this suborder are known as sawflies because the ovipositor is saw-like and fitted for making slits in leaves and stems in which to deposit the eggs.

Family Pamphiliidæ

The Web-spinning and the Leaf-rolling Sawflies

The common names given above were suggested by the fact that the larvæ of some species build nests by tying the leaves of their food plants together with a web of silk, and others build nests by rolling the edge of a leaf and live inside the tube so formed. The larvæ of some species are gregarious. The larvæ of members of this family have long, seven-jointed antennæ, well-developed thoracic legs, but lack abdominal prolegs.

The body of the adult is robust. The posterior margin of the pronotum is straight or nearly so. The mesonotum is short and never extends much beyond the anterior margins of the tegulæ. The anterior tibiæ are armed with two apical spurs. The ovipositor of the female is short.

More than fifty species have been described from America north of Mexico; but the larvæ of only a few of these are known; among these are the following.

The plum web-spinning sawfly, *Neurŏtoma inconspĭcua.* — The larvæ of this species feed on the foliage of plum and cherry; they are gregarious and form unsightly nests by spinning webs over the leaves; frequently these webs cover an entire tree. The injury is done in early summer. When full-grown the larvæ find their way to the ground, where they pass the remainder of the summer and winter in earthen cells; they transform to pupæ in the spring, and the adults emerge in May or June.

The peach sawfly, *Pamphĭlius pĕrsicus.* — This pest of the peach is one of the leaf-rolling species. The adults emerge from the ground late in May or early in June and lay their eggs on the leaves; the eggs soon hatch; each larva cuts a slit in a leaf and then rolls over a portion of the leaf, making a case within which it stays during the daytime, feeding chiefly at night. There is a single generation a year. The larva passes the winter in the ground.

Family Siricidæ

The Horn-tails

The common name horn-tails is applied to members of this family because the last abdominal segment bears a more or less horn-like prolongation. This is short and triangular in the males, and is a prolongation of the last ventral segment; in the females it is long and often spear-shaped, and is a prolongation of the last dorsal segment.

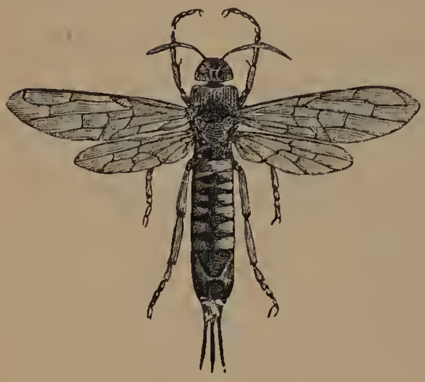
Fig. 577. — *Tremex columba.*

The body is cylindrical (Fig. 577); the head large and widened behind the eyes; the pronotum is right-angled, so that it presents both a strictly dorsal and a cephalic aspect, the latter concave; vein Sc_1 of the front wing is absent; the propodeum is divided longitudinally; the anterior tibiæ each with only one apical spur; the sheath of the ovipositor is very long and exserted beyond the end of the abdomen; the ovipositor is fitted for boring.

The Siricidæ is a small family; only about fifty species representing five genera are known.

The larvæ bore in the trunks of trees; our best-known species is the following one.

The pigeon horn-tail, *Trēmex colŭmba.* — The larva of this species infests maple, elm, apple, pear, beech, oak, and sycamore. The female (Fig. 577) in order to oviposit pierces the wood of a tree to the depth of about ½ of an inch; the eggs are laid singly; sometimes her ovipositor gets wedged in the wood and holds her a prisoner until she dies. The larva is cylindrical and attains a length of 1⅗ inches. It transforms within its burrow, in a cocoon made of silk and fine chips.

The adults of this species vary in color and marking; based on these variations, three fairly distinct races have been recognized, which to a considerable extent are geographical, although their ranges overlap. In the typical form, race *columba*, the abdomen is black, with ochre-yellow bands and spots along the sides; this is the common form in Quebec, Ontario, and the northeastern United States. In the race *aureus*, the ground color of the abdomen is yellow and the markings black; this is the common form in the Rocky Mountains and is found on the Pacific Coast. In the race *sericeus*, the entire body is fulvous, the legs beyond the femora yellow, and the wings dark reddish-brown; this race is found in the southeastern United States and as far north as Pennsylvania and West to Utah.

Family CEPHIDÆ

The Stem Sawflies

The stem sawflies are so-called because the larvæ bore into the stems of plants or in the tender shoots of trees and shrubs. The adults are slender, elongate insects of moderate size. The pronotum is more or less quadrate and longer than is usual in the Hymenoptera. The anterior tibiæ are armed with one terminal spur.

This family is of moderate size; less than a score of species have been found in our fauna; but these represent nine genera. Some of the species are of economic importance. Several species bore in the stems of grains and grasses. The following species illustrate the habits of these.

The wheat-sawfly-borer, *Cēphus pygmæus*. — The larvæ of this species bore in the stems of wheat, a single larva in a stem, dwarfing and stunting the growth of the plant. As the grain becomes ripe the larva works its way toward the ground; and at the time of harvest the greater number of them have penetrated the root. Here, in the lowest part of the cavity of the straw, they make preparations for passing the winter, and even for their escape from the straw, as adults, the following year. This is done by cutting the straw circularly on the inside, nearly severing it a short distance from the ground, so that a strong wind will cause it to break off at this point. After the circular cut has been made, the larva fills the cavity of the straw just below it for a short distance with a plug of borings. Between this plug and the lower end of the cavity, the wall of the cavity is lined with silk forming a cocoon within which the larva passes the winter and changes to a pupa in March or April. The adult insects emerge early in May.

The currant-stem girdler, *Jānus ĭnteger*. — The larva of this species bores in the upper portion of the canes of currant. Its presence is indicated by the wilting and drooping, in late spring, of the new growth at the tip of the infested cane. This is due to the fact that the parent sawfly after depositing her egg in the cane moves up a short distance above where the egg is deposited and with her ovipositor girdles the cane, sometimes nearly severing it. This killing of the tip, and thus checking the growth of the cane, seems to be necessary for the development of the egg and larva. The larva bores in the pith of the cane. In the fall it eats a hole through the woody wall of the cane to the outer bark, thus making provision for the escape of the adult, and then spins a cocoon in which it hibernates. The change to the pupa state takes place in April and the adult emerges in May. The obvious method of control of this pest is to remove and burn the infested portion of the canes while the larvæ are in them.

Family CIMBICIDÆ

The Cimbicid Sawflies

This is a small family, which is represented in our fauna by a few genera and a limited number of species. In this family the body is stout and often very large; there are distinct pleural sclerites in the abdomen (Fig. 578) and the antennæ are clavate. The sheath of the ovipositor extends but little if at all beyond the end of the abdomen.

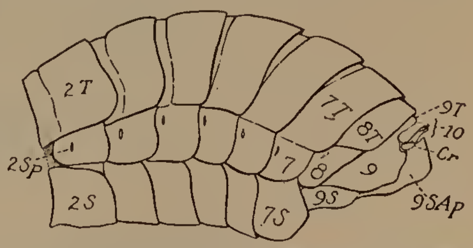

FIG. 578. — *Cimbex americana*. Abdomen except first segment: *7*, *8*, *9*, pleurites; *T*, *T*, *T*, tergites; *S*, *S*, *S*, sternites; *cr*, cercus; *sp*, spiracle. (After Snodgrass.)

The body of the larva is cylindrical, stout, and covered with a waxy bloom when living; the thoracic legs are well-developed and five-jointed; and the abdomen bears eight pairs of prolegs. The larvæ live free upon foliage upon which they feed.

The American sawfly, *Cĭmbex americāna*. — This is the largest of our common sawflies. The female is about $\frac{2}{5}$ of an inch in length and has a black head and thorax, a steel-blue or purplish abdomen, with four yellowish spots on each side, smoky-brown wings, and black legs, while her feet and short, knobbed antennæ are pale yellow. The male is longer and slenderer and differs somewhat in color. Several varieties of this species, differing in color, have been described. The eggs are laid in June in crescent-shaped slits made in leaves. The food plants are elm, birch, linden, and willow. The larva is greenish-yellow, with black spiracles and a black stripe down its back. When disturbed it spurts forth a fluid from glands just above the spiracles. It clings to the upper surface of a leaf and feeds on the edge of the leaf. When not feeding it rests on one side with the body curled up in a spiral form. There is but one generation each year. When the larva is full-grown it burrows in the ground, makes an oval, brownish cocoon, and there spends the winter, not changing to a pupa until spring. The adults appear in May or June.

Family TENTHREDINIDÆ

The Typical Sawflies

This is a very large family, including more than seven-eighths of all of the members of the suborder Chalastogastra.

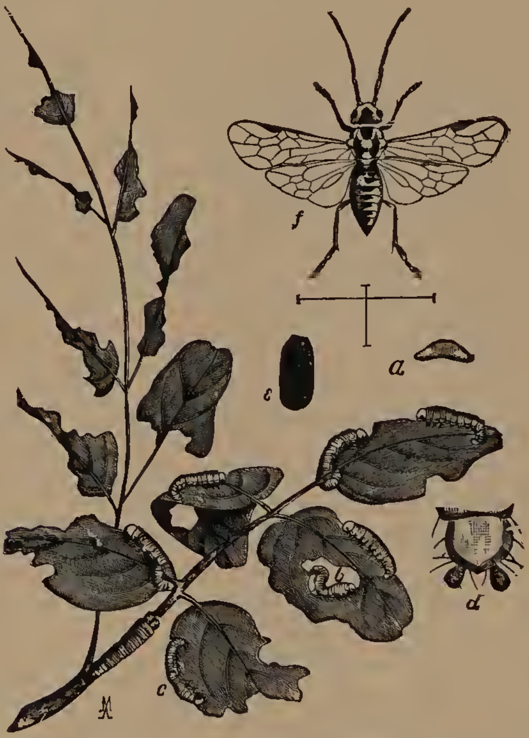

FIG. 579. — The locust sawfly, *Pteronidea trilineata*: *a*, egg; *b*, young larva; *c*, full-grown larva; *d*, anal segment of full-grown larva; *e*, cocoon; *f*, adult.

The larvæ are caterpillar-like; the thoracic legs are always present and are usually well developed, but are vestigial in some species. Prolegs are usually present; these are borne on abdominal segments 2–7 and 10 or 2–8 and 10, rarely the prolegs are vestigial. The larvæ of the different species differ greatly in size varying from $\frac{2}{5}$ to $1\frac{3}{5}$ inches in length.

The larvæ of the majority of the species live free on the foliage of plants, upon which they feed (Fig. 579). The larvæ of some species are leaf-miners; some make galls on stems and leaves of plants. Among the species that have attracted attention on account of their economic importance are the following.

The imported currant-worm, *Pteronĭdea ribēsi.* — This is the commonest and best-known of the garden pests. The adult sawflies appear early in the spring and the females lay their eggs in rows along the principal veins on the underside of the leaves of currants and gooseberries. They hatch in a week or ten days; and the larvæ begin at once to feed upon the leaves. The larvæ are at first whitish, as they increase in size the color changes to green; after the first molt the body becomes covered with many black spots and the head is black; at the last molt they lose their black spots and assume a uniform green color tinged with yellow at the ends. When full-grown the larvæ descend to the ground and spin their cocoons, either just below the surface of the ground or beneath rubbish; sometimes the cocoons are attached to the stems or leaves some distance from the ground. A second generation of the sawflies appears late in June or early in July; and sometimes a third generation is developed.

The pear-slug, *Calĭroa cĕrasi.* — This is a well-known pest of pear, cherry, and plum. It causes the leaves of the infested tree to turn brown. When such leaves are examined it is found that the injury is due to small, slimy, slug-like larvæ, which have eaten off the upper surface of the leaves, leaving the skeleton of veins and the lower epidermis to turn brown, wither and fall; sometimes trees are entirely defoliated in this way by midsummer. When full-grown the larvæ descend and burrow into the ground a short distance, where each constructs an earthen cell in which it transforms. A second generation of the sawflies appear and lay their eggs about three weeks later.

The rose-slug, *Clădius isŏmerus.* — Often in the summer our rose-gardens look as if fire had swept over them, so scorched and brown are the leaves. The cause of this apparent conflagration is a transparent jelly-like slug, greenish above and yellowish below, which eats the upper surface of the leaves, leaving patches of the lower surface and the veins. These slugs usually feed by night and remain hidden on the lower surface of the leaves by day. When ready to pupate they crawl down or drop to the ground and burrow beneath the surface; here each makes a little cell and then transforms. The adult fly is shining black with smoky wings and with the fore and middle legs grayish or dirty-white. The female is about $\frac{1}{4}$ of an inch in length. There are two broods a year, one in June and one in August. The last brood passes the winter in the ground.

Suborder IDIOGASTRA *

The Oryssids

This suborder, includes a single small family of rare insects, the Oryssidæ, which formerly was included in the suborder Chalastogastra.

The suborder Idiogastra stands intermediate between the other two suborders of the Hymenoptera. In this suborder the adults (Fig. 580) resemble the Chalastogastra in the shape of the abdomen; but the form and habits of the larvæ are those characteristic of the Clistogastra. The distinctive characteristics of the Idiogastra are those of the single family included in it.

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* Idiogăstra: *idio* (ἴδιος), distinct; *gastros* (γαστρός), the belly.

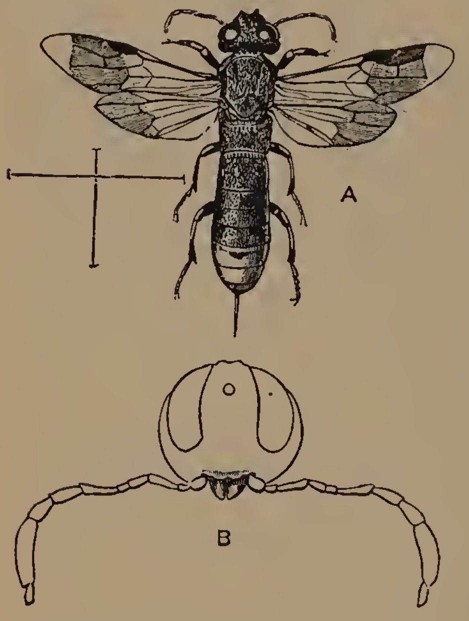

Fig. 580. — *Oryssus sayi;* A, female; B, head seen from in front. (From Sharp.)

Family Oryssidæ

The Oryssids

In the shape of the body the members of this family strongly resemble the Siricidæ. They are easily distinguished, however, from all of the Chalastogastra by the anomalous position of the antennæ, which are inserted far below the eyes, immediately above the mandibles, under a transverse ridge; by the more reduced venation of the wings; and by the remarkable form of the ovipositor.

In the form of the ovipositor and in its position when at rest the Oryssidæ differ from all other Hymenoptera. For a description of the ovipositor the student is referred to "An Introduction to Entomology" by J. H. Comstock, p. 904.

The Oryssidæ is a widely distributed family, members of it having been found in all of the major geographical regions of the world. But it is a small family, including only a few genera and species. A single genus, *Ory̆ssus*, is found in North America, of which about a dozen species have been described from this region.

The adults are very active and are found running over the trunks of trees and on timber. The larvæ were formerly supposed to be borers in the trunks of trees; but it has been shown that they are parasitic on the larvæ of *Buprestis* and probably on other wood-boring larvæ.

The larva of only a single species, *Oryssus occidĕntalis*, is known. This is white, subcylindrical, about one-third as thick as long, and legless; but the positions of the legs are indicated by chitinized disks. The mouth-parts are very simple, the labrum, labium, and maxillæ being merely fleshy lobes, but the mandibles are hard and horn-like; the antennæ are tubercle-like and set at the summits of rounded elevations.

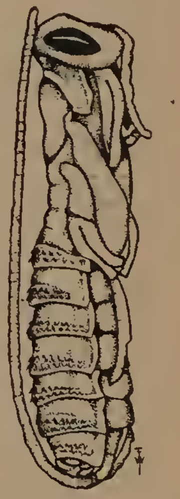

Fig. 581. — Pupa of *Oryssus*, female. (After Rohwer and Cushman.)

In the pupa of the female (Fig. 581) the terminal portion of the ovipositor is external and extends over the back the entire length of the body. This long, slender, external form of the ovipositor in the pupa is rather remarkable, especially in view of the very different form it assumes in the adult female.

Suborder CLISTOGASTRA *

The Parasitic Hymenoptera, and the Ants, Wasps, Bees, and Allies

The most striking characteristic of this suborder is the fact that what appears to be the first abdominal segment, but which is really the second, is greatly constricted forming a slender petiole or waist between the larger portion of the abdomen and the alitrunk or wing-bearing region of the body (Fig. 582).

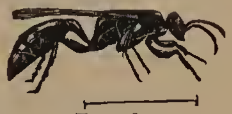

Fig. 582.

In this suborder the intermediate region of the body is not merely the thorax but includes also the first abdominal segment, only the tergum of which is preserved in the adult. This is known as the *median segment*, or the *propodeum* and can be identified by its spiracles, the third pair of this region of the body. It should be remembered that the thorax bears only two pairs of spiracles. From the above it follows that what appears to be the first abdominal segment in the Clistogastra, and which is usually so-called, is really the second.

In some the ovipositor is a boring instrument by means of which deep holes are made into trees and eggs placed in these holes; in others it is used for thrusting the eggs into the bodies of other insects; and in still others it is modified so as to form a sting with which poison glands are connected.

THE PARASITIC HYMENOPTERA

When the discouraged farmer sees his crops harvested before due time by hordes of hungry insects, he is apt to long for a miracle to remove the plague from his fields. Oftener than he dreams the miracle takes place, and millions of insect pests never live to lay their eggs for another brood. Such miracles are frequently wrought by members of a large group of insects, which is commonly known as the parasitic Hymenoptera.

Although some of these insects are external parasites, most of them live within the bodies of their hosts, within which they pass their entire larval existence. Their presence in this strange situation is due to the fact that the parent lays her eggs within or upon the body of the victim. When the egg is laid upon the body of the victim the larva as soon as it hatches bores its way into the body. So in either case the young parasite is in the midst of suitable food. It is probable that the parasite feeds at first only on the blood of its host; hence the parasitized insect is not destroyed at once, but lives on with the parasite within it, which gradually attains its growth. Finally, the parasitized insect perishes; and from the larva that has been nourished in its body there is developed a winged creature, which in turn lays its eggs in other victims. Frequently a parasitic insect lays several eggs within a single victim, so that a number of parasites may be developed within the body of a single insect. Each species of these parasites infests only certain insects, each insect having, to a great extent, its peculiar parasites.

The parasitic Hymenoptera does not constitute a natural division of the order but includes representatives of many families.

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* Clistogastră: *clisto* (χλειστός), closed; *gastros* (γαστρός), the belly.

Family Braconidæ

The Braconids

The family Braconidæ includes a large number of species, which are small or of moderate size. In this and in the following family the costal cell of the fore wings has been eliminated by the coalescence of veins (Fig. 583) and the venter is membranous and has in dried specimens a longitudinal fold.

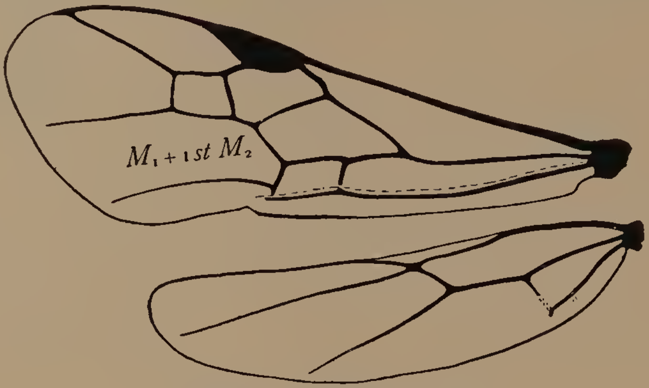

Fig. 583. — Wings of a braconid.

It is not an uncommon thing, especially in vineyards to find a feeble caterpillar with its back covered with little, white, oblong bodies, which the uninformed usually think are eggs (Fig. 584). These are the cocoons of braconid parasites. The larvæ obtain their growth within the body of the caterpillar, and just before it perishes they leave it, and spin their silken cocoons upon its back. When these cocoons are examined with a lens they are found to be beautiful objects, resembling in miniature those of the silkworm. The adult parasite in emerging from its cocoon cuts a neat little lid at its upper end. These parasites belong to the genus *Microgaster*. Bunches of white or yellow cocoons of *Microgaster* are often found attached to grass or other plants instead of to the back of the caterpillar which the larvæ have destroyed (Fig. 585).

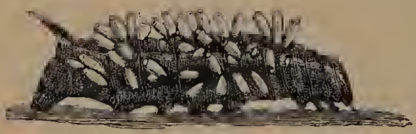

Fig. 584. — Caterpillar with cocoons of a braconid.

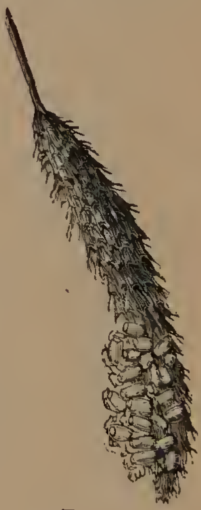

Fig. 585.

Perhaps the most interesting of the common forms belonging to this family are those belonging to the genus *Aphĭdius*. The members of this genus are minute creatures which infest plant-lice. If colonies of aphids be examined, the dried bodies of dead ones may be found in which the abdomen is more or less spherical, being greatly distended. These bodies remain clinging to the leaves in the position in which the insects were when they died. From each one there emerges in due time an *Aphidius*. The parasite in emerging cuts a very regular circular lid in the dorsal wall of the abdomen of its host (Fig. 586). We have watched with much

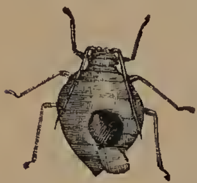

Fig. 586.

interest these little braconids ovipositing in the bodies of plant-lice. When one has selected a plant-louse in which to oviposit she stands with her head toward it, and bending her abdomen under her thorax between her legs she darts her ovipositor forward into the body of the aphid. The species of this genus do not construct cocoons, but undergo their metamorphosis within the dried skins of plant-lice.

Family Ichneumonidæ

The Ichneumon-flies

This is a large family including a great number of genera and species. Although it includes some minute forms the species are mostly of considerable size, and here belong the larger of the parasitic Hymenoptera.

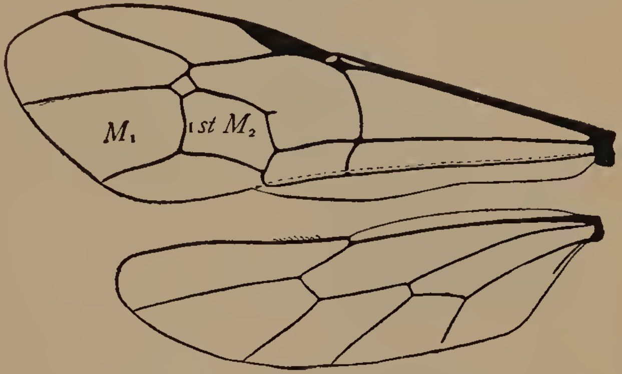

Fig. 587. — Wings of an Ichneumon fly.

In this family, as in the preceding one, the costal cell of the fore wings has been eliminated by the coalescence of veins and the venter is usually membranous and has in dried specimens a longitudinal fold (Fig. 587).

Students collecting Hymenoptera will find many species of ichneumon-flies; and those attempting to rear caterpillars will be disappointed often by the breeding of ichneumon-flies instead of moths or butterflies.

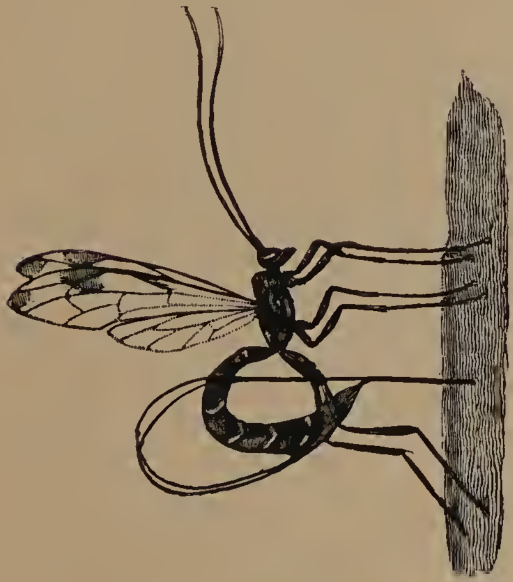

Fig. 588. — *Megarhyssa lunator.*

Megarhy̆ssa lunātor, which was formerly known as *Thalĕssa lunātor*, is one of the larger of ichneumon-flies (Fig. 588). It is a parasite of the wood-boring larva of the pigeon horn-tail, *Tremex columba*. When a female finds a tree infested by this borer she selects a place which she judges is opposite a Tremex-burrow, and elevating her long ovipositor in a loop over her back, with its tip on the bark of the tree (Fig. 588), she makes a derrick out of her body and proceeds with great skill and precision to drill a hole into the tree. When the Tremex-burrow is reached she deposits an egg in it. The larva that hatches from this egg creeps along this burrow until it reaches its victim, and then fastens itself to the horn-tail larva, which it destroys by sucking its blood. The larva of *Megarhyssa* when full-grown changes to a pupa within the burrow of its host, and the adult gnaws a hole out through the bark if it does not find a hole already made by the *Tremex*. Sometimes the adult *Megarhyssa*, like the adult *Tremex*, gets her ovipositor wedged in the wood so tightly that it holds her a prisoner until she dies.

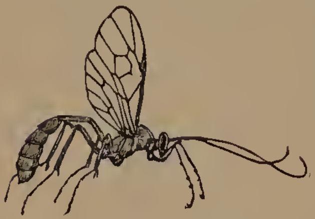

Fig. 589. — *Ophion.*

Among the more common of our larger Ichneumon-flies are those of the genus *Ophion* (Fig. 589); these have yellow bodies. One species infests the caterpillars of the Polyphemus moth and only a single egg is laid within each victim. The caterpillar lives until it spins a cocoon, but does not change to a pupa. The Ichneumon larva when full-grown spins a dense brownish cocoon within the cocoon of the caterpillar.

Family Proctotrupidæ and Allies

The Proctotrupoids

There is a group of nine closely related families of the Hymenoptera which together are known as the proctotrupoids. The group, as a whole, is of great economic importance because the different species are parasitic upon a great variety of insects.

The members of this group are slender insects and mostly of minute size. Their color is almost invariably black or brown without metallic luster. The venation of the wings is greatly reduced and in many forms the wings are veinless; there are also many wingless species. Figure 590 represents a proctotrupoid greatly enlarged.

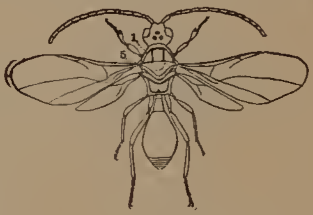

Fig. 590.

The proctotrupoids are all parasitic wasps; and very many of them infest the eggs of other insects. The female proctotrupid bores a hole with her ovipositor through the shell of an egg of one of the larger insects, and deposits one of her eggs inside of it. Here the young parasite when it hatches finds itself in the midst of food which is sufficient for it till it is fully grown. The transformations are passed within the infested egg, from which the parasite comes forth an adult. Other species are internal parasites of larvæ, and some are secondary parasites, that is, parasites upon other parasites. None has been found to be injurious to vegetation.

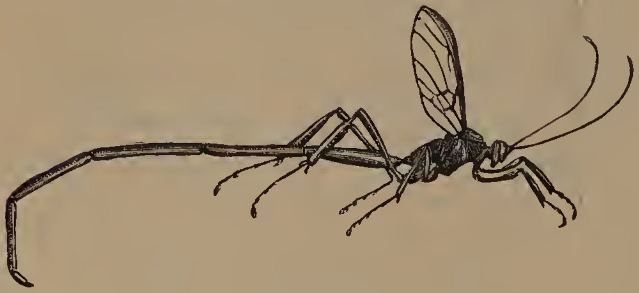

Fig. 591.

Perhaps the most remarkable species of the proctotrupoids is *Pelecīnus polyturātor*, the only representative in our fauna of the family, Pelecinidæ. The females are common in the regions in which the species occurs and are easily recognized by the long and slender abdomen (Fig. 591). The abdomen of the male is club-shaped and only about twice as long as the head and thorax. This sex is very rare in this country but is common in some parts of South America; it can be recognized by the venation of the wings, which is similar to that of the female. This species is parasitic on the larvæ of May-beetles.

Family CYNIPIDÆ

The Cynipids

Most members of this family are small insects and many of them are minute; for this reason they are not commonly observed; but the galls produced by some species, especially those that are found on oaks and roses, are very familiar objects. Not all cynipids, however, produce galls; some are parasites and others are inquilines, living in galls produced by other species.

The antennæ of the cynipids are not elbowed and only rarely composed of more than sixteen segments; the pronotum is produced on each side so as to reach the tegula or is separated from it only by a membranous area; the wings lack a stigma and have at most five closed cells; the wings are rarely wanting; the abdomen is strongly compressed.

In most of the cynipids the dorsal sides of the basal segments of the abdomen are very long and appear to project over and cover the last segments so that only the edges of the latter are visible (Fig. 592).

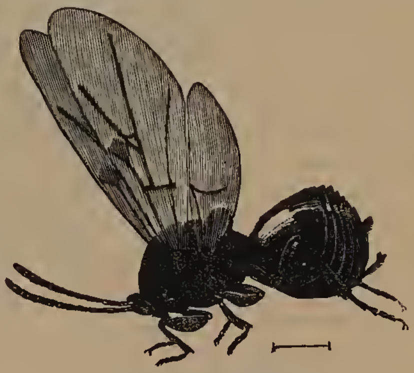

FIG. 592. — *Amphibolips.*

The cynipids are of interest because some of them are parasitic on other insects, especially aphids and the larvæ of flies, and because some cause galls on various plants.

The work of the gall-producing species is much more conspicuous than that of the parasitic forms and more is known about the gall-makers which are commonly known as gall-flies. It should be remembered, however, that galls on plants are produced by other insects, namely, plant-lice, flies, moths and occasionally beetles and also by mites. In the case of galls made by the cynipids the gall is closed and a hole must be made by the insect in order to emerge. Moreover, there is no reproduction of insects within the galls of gall-flies, as there is within the galls of mites and plant-lice.

It is a remarkable fact that each species of gall-insects infests a special part of one or more particular species of plants, and the gall produced by each species of insect is of a definite form. Hence when an entomologist who has studied these insects sees a familiar gall, he knows at once what species of insect produced it.

Naturalists have speculated much as to the way galls are made to grow. It has been supposed that at the time the egg is laid there is deposited in the tissue of the plant with it a drop of poison, which causes the abnormal growth. By this theory the differences between the galls of different insects was explained by supposing that the fluid produced by each species of insect had peculiar properties. There are certain kinds of galls which may be produced in this way. Thus it is said that the wound made by a certain sawfly in the leaves of willow causes an abundant formation of plant-cells, and the gall thus formed attains its full growth at the end of a few days, and before the larva has escaped from the egg. But with the gall-flies the gall does not begin to grow until the larva is hatched; but as soon as the larva begins to feed, the abnormal growth of the plant commences. In this case, therefore, if the gall is produced by a poison, this poison must be excreted by the larva.

Galls produced by the different species of cynipids differ greatly in form and are found on all parts of plants.

There are two terms that are frequently used in the descriptions of galls; these are *monothalamous*, indicating that the gall contains a single larval cell, and *polythalamous* indicating that the gall is compound, containing more than one larval cell.

Certain insect-galls have been found valuable for various purposes; they have been used in medicine, in the manufacture of ink, for tanning, and for dyeing.

There exists in many species of gall-flies an alternation of generations; that is, the individuals of one generation do not resemble their parents, but are like their grandparents. In many cases the two succeeding generations of a species differ so greatly that they have been considered as distinct species until by careful studies of the life-cycle one has been found to be the offspring of the other. In those species where an alternation of generations exists, one generation consists only of agamic females while the other consists of both males and females, which reproduce sexually. In some cases the galls produced by the two generations are quite similar; but in others they are very different and are found on different parts of the host-plant.

The guest gall-flies or inquilines. — Some species of this subfamily do not form galls but lay their eggs in the galls made by other species. The larvæ of these inquilines feed upon the galls produced by their hosts and in some cases do not discommode the owners of the galls in the least. But some guest gall-flies are parasites as well as guests and their larvæ mine from cavity to cavity of the gall and feed on the occupant of each in turn.

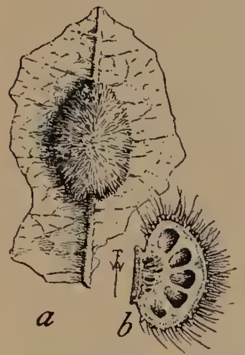

Fig. 593. — The oak hedgehog gall: *a*, gall on leaf; *b*, section of gall.

Among the more conspicuous of our cynipid galls are the following.

The oak hedgehog gall, *Andricus erinācei.* — A common gall on the leaves of white oak is one known as the oak hedgehog gall. This gall is rounded or oblong, with the surface finely netted with fissures, and more or less densely covered with spines (Fig. 593, *a*). It varies in length from $\frac{2}{5}$ to $\frac{3}{5}$ of an inch, and occurs on both sides of the leaves. The point of attachment is generally on the midrib, though it is often found on the lateral veins. When young the gall is yellowish-green, but in autumn it becomes yellowish-brown. This gall is polythalamous, containing from two to eight larval cells (Fig. 593, *b*).

Within the hedgehog galls is developed one generation, the agamic one, of *Andricus erinacei.* The alternating generation, the sexual one, is developed in very different galls made on the terminal growing points of buds and bud-scales. These are small, thin-walled, elongate, egg-shaped galls from $\frac{1}{12}$ to $\frac{1}{8}$ of an inch in length, and are monothalamous.

The oak-apples. — There are various kinds of galls found on the leaves and stems of oaks that are commonly known as oak-apples, a name suggested by the spherical form and large size of some of them. Several of these are quite similar in external appearance but are markedly different in internal structure. In all there is a firm outer wall and a small, central larval cell (Fig. 594). The part of the gall between the larval cell and the outer wall differs in structure in the galls of different species of gall-flies; in some it is filled with a spongy mass of tissue, in others the larval cell is held in place by a small number of filaments that radiate from it to the outer wall.

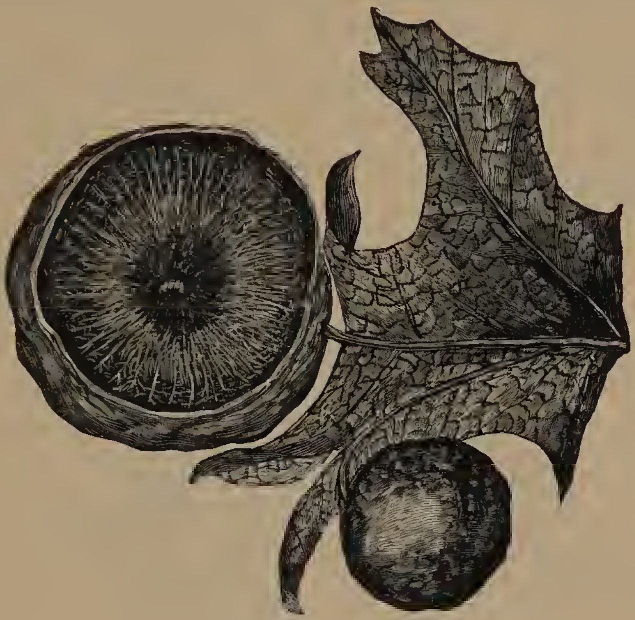

Fig. 594. — An oak-apple.

The large oak-apple, *Amphĭbolips conflūens.* — This is the largest of our common oak-apples, measuring from 1 to 2 inches in diameter. It occurs on several species of oak and is usually attached to a vein or the petiole of a leaf. The space between the larval cell and the outer wall of the gall is filled with a spongy mass of tissue, in which in some of the galls there are many radiating fibers, as shown in the figure above, but in other galls these fibers are indistinct, the space being filled with an amorphous mass of tissue.

In spite of the fact that these galls are common and conspicuous the life-cycle of the species that produces them has not been fully worked out.

The large empty oak-apple, *Amphĭbolips inānis.* — In this gall the space between the central larval cell and the outer shell contains only a few, very slender, silky filaments, which hold the larval cell in place (Fig. 595). The gall measures from 1 to $1\frac{2}{5}$ inches in diameter, and is found on the leaves of the scarlet oak and red oak. Externally this gall resembles

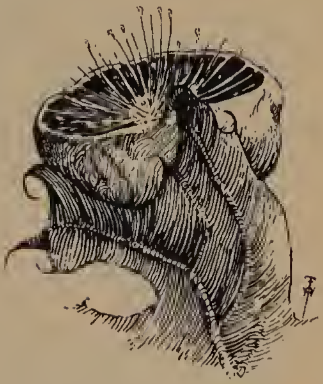

Fig. 595. — The large empty oak-apple.

that of the preceding species but is easily distinguished by its internal structure. The adult gall-flies emerge in June and early in July; they are male and female; an agamic form of this species is not known.

The giant oak-gall, *Ăndricus califŏrnicus.* — This is the most common oak-gall of the Pacific Coast. It is very abundant on the twigs and branches of the California white oaks, and during the winter, when the trees are bare, it is a very conspicuous object, on account of its abundance and large size. It varies in shape from globose to reniform and also varies greatly in size, some of the larger ones measure more than 4 inches in their greatest diameter. The outer surface of the gall is white and usually smooth; the interior is more or less filled with a compact soft material, and contains from one to a dozen larval cells.

The mossy rose-gall, *Rhodītes rōsæ.* — This is a very common polythalamous gall, which is formed on the stems of rose bushes, especially of the sweetbrier. The gall consists of a large mass of moss-like filaments surrounding a cluster of hard kernels (Fig. 596). In each of these kernels a gall-fly is developed. The galls appear early in the summer but the adults do not emerge till the following spring. These are male and female; there is no alternation of generations in this species.

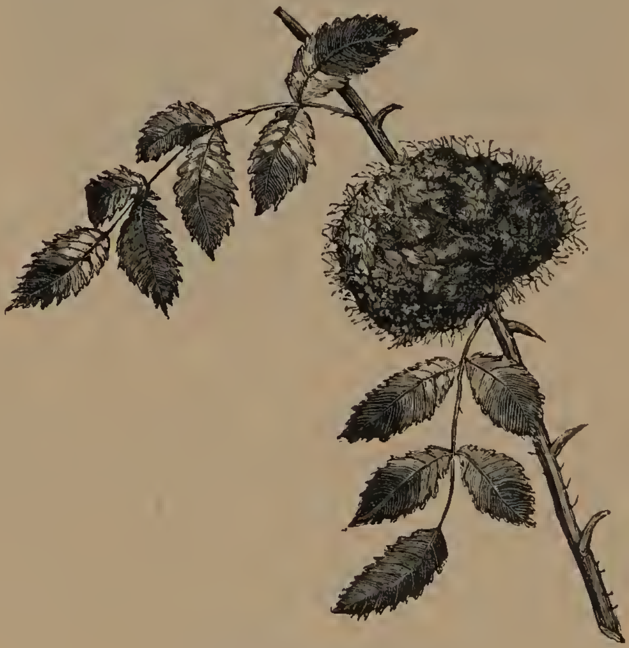

Fig. 596. — The mossy rose-gall.

Family Chalcididæ

The Chalcid-flies

This family is a very large one for it includes many thousands of species. Most of the species are very small insects and some are minute, measuring not more than a quarter of a millimeter in length; some species are much larger but these do not exceed the honey-bee in size. Most of the species are black, with strong metallic reflections, although some are yellow and some of the larger species have red markings. The head is usually large (Fig. 597); the prothorax does not extend back on each side to the tegula; the ovipositor is usually hidden, issuing before the apex of the abdomen, but in some genera it is very long.

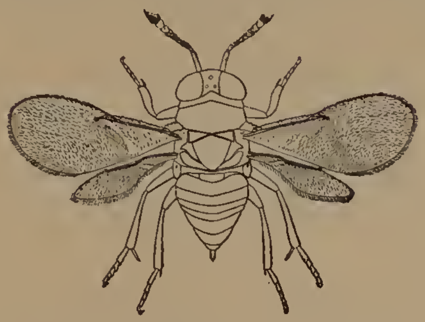

FIG. 597. — A chalcid-fly, *Aphycus eruptor*.

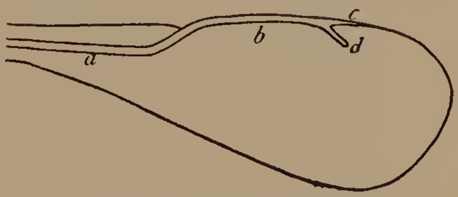

FIG. 598. — Fore wing of a chalcid-fly.

In most of the chalcids the venation of the wings is reduced to the type shown in Figure 598; in a few, however, there are vestiges of other veins; but in none are there any closed cells.

The chalcid-flies constitute an exceedingly important group of insects from an economic standpoint; and nearly all of them are beneficial, being parasites that do much to keep in check noxious insects. A few species, however, are phytophagous; among these are those of the genus *Isosoma*, now known as *Harmolita*, that infest the stalks of growing grain, and species of several genera that infest the seeds of various plants. While these are noxious, the fig-insects, although phytophagous, are very beneficial to man.

Insects in all stages of their development suffer from the attacks of chalcid-flies, eggs, larvæ, pupæ, and even adults in a few cases being attacked by them. The larvæ of chalcid-flies usually feed within the body of their host, (Fig. 598a) but some species are external parasites of other larvæ.

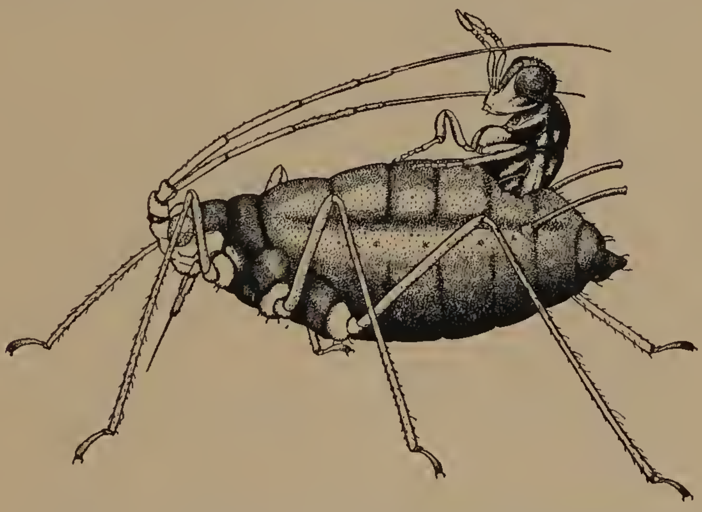

FIG. 598a. — A chalcid parasite, *Aphelinus jucundus*, emerging from the geranium aphid. (Figure loaned by Dr. Grace H. Griswold.)

The plant-feeding chalcids are of considerable interest because they are destructive to crops. The following are well-known.

The wheat joint-worm, *Harmolīta trĭtici.* — This is a well-known pest which infests the stalks of growing wheat and certain grasses. It causes a woody growth which fills up the cavity of the stalk, and sometimes also causes a joint to swell and the stalk to bend and lop down. The presence of this insect is often indicated by pieces of hardened straw coming from the threshing machine with the grain. There is but a single generation of this species in a year. The insect remains in the straw and stubble during the winter, the adults emerging in the spring. The methods of control of this pest are rotation of crops, burning or deep ploughing under of stubble when practicable, or harvesting of stubble in spring with a horse-rake and burning it before the adults emerge.

The wheat straw-worm, *Harmolīta grăndis.* — This species is often a serious pest of wheat west of the Mississippi River; it also occurs in the East, but is rarely so injurious in this section as is the wheat joint-worm. The adults differ from our other species of *Harmolita* in that the mesonotum is smooth, polished, and shining. This species also differs in that it exhibits a seasonal dimorphism. There is a summer generation, which consists only of winged females, and a winter and spring generation which consists of both males and females. These are smaller than the summer form and are frequently wingless. The adults of the winter and spring generations emerge in April and the females deposit their eggs in the young wheat plants; the larvæ eat out and totally destroy the forming heads of wheat. The adults of the second generation deposit their eggs, about the time the wheat is heading, just above the youngest and most succulent joints which are not so covered by the enfolding leaf-sheaths as to be inaccessible to them. The larvæ pupate by October and the winter is passed in the straw or stubble.

Another species that is of economic importance is the clover-seed chalcid, *Bruchŏphagus funēbris*, which infests the seeds of red and crimson clovers and alfalfa. This insect usually winters over in the seed as a well-developed larva; the pupal stadium is rather short and the adult lays her eggs in May and June.

The fig-insects. — These are remarkable chalcids that live within figs and fertilize them. There is but a single species in the United States, *Blastŏphaga psēnes*, which was introduced into California in order to make possible the production of the Smyrna fig in that state.

The fruit of the fig-tree consists of a hollow receptacle on the lining of which the flowers are borne. At the apex of the fig there is a more or less distinct opening leading into the interior; it is through this opening that the female fig-insect leaves the fig in which she was developed and enters a young fig in order to oviposit.

The eggs are laid at the base of a modified form of pistillate flowers, known as gall-flowers, that are found in wild figs; and the larvæ produce little galls in which they develop. The female fig-insect when leaving the fig in which she was developed becomes covered with pollen which is thus carried into the young fig which she enters to oviposit, and thus the flowers in this fig are fertilized.

The male fig-insect is wingless. It crawls about over the galls in the fig in which it was developed and when it finds a gall containing a female it gnaws a hole in it and then thrusting the tip of its abdomen through the puncture fertilizes the female.

It is only in the wild figs that the gall-flowers are developed; for this reason only the wild figs are suitable for the development of the fig-insects; but the female fig-insects will enter the cultivated figs seeking a place to oviposit and will thus fertilize them.

Although the numerous varieties of common, cultivated figs do not require the stimulus of pollination and the resulting fertilization of the ovary to make the fruit set, in the case of the Smyrna fig, which is the most desirable variety grown, without this stimulation the young figs soon turn yellow and drop. It is the oily kernel of the fertile seed that gives the Smyrna figs their superior quality.

The fertilization of the edible figs is termed caprification; and it is brought about by placing in the fig-trees fruit of the wild figs containing the fig-insects. In order, therefore, to produce the Smyrna figs it is necessary to grow also the wild figs, or caprifigs as they are termed.

There are many species of fig-insects living in the wild figs of tropical and semi-tropical countries.

THE COMMON WASPS, ANTS, AND ALLIES

This is a large group of hymenopterous insects which are closely related in certain details of external structure but which vary considerably in habits and appearance. It includes the well-known wasps and hornets, the ants, the velvet-ants, the tiphiid wasps and others, some fourteen families in all, of which only a few can be discussed here.

Family POMPILIDÆ

The Spider-wasps

The members of this family are commonly called spider-wasps, because they provision their nests with spiders; this habit, however, is not distinctive as certain other wasps use spiders for this purpose.

The members of this family are slender in form, with long spiny legs. The pronotum extends back on each side to the tegula; and the abdomen is sessile. Many of the species are of medium size, but some are very large; in fact, the largest of our Hymenoptera belong to this family.

Most of the Pompilidæ make their nests in the ground. The wasp first finds a spider and stings it until it is paralyzed, and then digs a burrow, which is enlarged at the lower end, forming a cell for the reception of the spider; the spider is then dragged down into the cell and an egg attached to it; then the passage leading to the cell is filled with earth.

Among the giants of this family are the well-known tarantula-hawks of the genus *Pĕpsis* of the Southwest, which store their burrows with tarantulas. Many a hard-fought battle do these spider-wasps have with these enormous spiders, and sometimes they are conquered and ignominiously eaten.

Not all members of this family are digger-wasps, for some are mason-wasps. The species of one genus make thimble-shaped cells, of mud, attached to the lower surface of stones, in chinks of walls, under bark and in various other situations. The books, "Wasps Social and Solitary," by the Peckhams, and "Wasp Studies," by the Raus, contain most interesting accounts of these wasps.

Family CHRYSIDIDÆ

The Cuckoo-wasps

The cuckoo-wasps are wonderfully beautiful creatures, being usually a brilliant metallic green in color. The species are of moderate size, the largest being only about ½ of an inch in length. They can be distinguished from other Hymenoptera by the form of the abdomen, in which there are at most five and usually only three or four exposed segments (Fig. 599), and which is strongly concave below, so that it can be readily turned under the thorax and closely applied to it. In this way a cuckoo-wasp rolls itself into a ball when attacked leaving only its wings exposed.

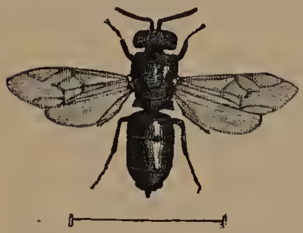
FIG. 599. — *Chrysis nitidula.*

The cuckoo-wasps are so-called because they are parasitic in the nests of solitary wasps and solitary bees. A cuckoo-wasp seeks until it finds a wasp or bee building its nest, and when the owner of the nest is off collecting provisions steals in and lays its egg, which the unconscious owner walls in with her own egg. Sometimes the cuckoo-wasp larva eats the rightful occupant of the nest, and sometimes starves it by eating up the food provided for it. The bees and wasps know this foe very well, and tender it so warm a reception that the brilliant-coated little rascal has reason enough to double itself up so the righteous sting of its assailant can find no hole in its armor. There is one instance on record where an outraged wasp, unable to sting one of the cuckoo-flies to death, gnawed off her wings and pitched her out on the ground. But the undaunted invader waited until the wasp departed for provisions, and then crawled up the post and laid her egg in the nest before she died.

Family TIPHIIDÆ

The Tiphiids

The tiphiids are mentioned mainly because of the species, *Tĭphia inornāta*, which is parasitic on white grubs, the larvæ of May-beetles. In order to reach the grubs, the wasp has to burrow into the soil until she finds her victim which she seizes with her mandibles and stings it in order to quiet its struggles. She then lays an egg on the back of the grub. The egg hatches and the larva eventually destroys its host.

The female tiphia is a black shining wasp about one-half an inch in length (Fig. 600). The male is smaller and has an upward projecting spine near the tip of the abdomen.

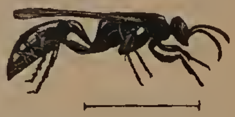
FIG. 600. — *Tiphia inornata.*

Family MUTILLIDÆ

The Velvet-ants

These handsome insects resemble ants in the general form of the body, but lack the scale-like knot of the pedicel of the abdomen characteristic of the true ants, although there is sometimes a constriction between the first and second abdominal segments (Fig. 601). The body is often densely clothed with hair, which gives the insects the appearance of being clothed in velvet; and as the body is usually ringed or spotted with two or more strongly contrasting colors, they are very conspicuous. But in many species the body is naked. The colors most commonly worn by the velvet-ants are black and scarlet. The males are winged and frequent flowers. The females are wingless, but they run very rapidly and they sting severely. In the western states there are many straw yellow species, which are nocturnal.

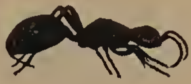

Fig. 601.

These insects are abundant in the warmer portions of our country, and several species occur in the North. A large species, *Dasymutĭlla occidĕntalis*, which measures from $\frac{3}{5}$ to $1\frac{1}{5}$ inches or more in length, is known in the South as the "cow-killer ant" because of the popular superstition that its sting is very dangerous to live stock.

The mutillids of which the habits have been observed are parasites of nest-building Hymenoptera in the cells of which they deposit their eggs. The larvæ attack those of the owners of the nest without touching the provisions which the cell may contain.

Family Scoliidæ

The Scoliids

The scoliids are quite closely related to the preceding family but differ in their general appearance, resembling wasps rather than ants. They are parasitic on white grubs, the larvæ of Scarabæidæ. In their habits they do not exhibit as much intelligence as do most digger wasps; for they do not build nests and transport prey to them for their carnivorous larvæ. Instead of this they dig in the ground where the white grubs are, and finding one they sting it in order to paralyze it, work out a crude cell about it, and attach an egg to a ventral abdominal segment of the grub. The larva of the scoliid consumes the grub and then spins a cocoon and completes its development in this place.

The members of this family are very striking in appearance, being of large size and with the abdomen marked with conspicuous spots. Two genera are represented in our fauna, *Scōlia* and *Campsomĕris* (*Elis*).

Family Formicidæ

The Ants

The great number of ants and their wide distribution render them the most familiar of all insects except perhaps the housefly. As has been said by Professor Wheeler, an indefatigable investigator of these insects, "Ants are to be found everywhere, from the arctic regions to the tropics, from timberline on the loftiest mountains to the shifting sands of dunes and seashores, and from the dampest forests to the driest deserts. Not only do they outnumber in individuals all other terrestrial animals, but their colonies even in very circumscribed localities often defy enumeration." The present time has been termed the "age of insects" and of all insects the Formicidæ is the dominant family.

Ants are easily recognized by the well-known form of the body. The most distinctive feature is the form of the pedicel of the abdomen; this consists of either one or two segments, and these segments are either nodiform or bear an erect or inclined scale (Fig. 602).

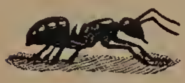
FIG. 602.

When the pedicel of the abdomen consists of a single segment it is known as the *petiole;* when it consists of two segments the first segment is termed the *petiole* and the second segment the *postpetiole*. The swollen portion of the abdomen behind the pedicel is known as the *gaster*.

Another striking characteristic of ants is that in the antennæ of females and workers and of the males of some species the basal joint, the scape, is long and the antennæ are abruptly elbowed at the extremity of this joint.

The ants are all social insects, there being no solitary species. Each colony consists of three castes, the males, the female or queen, and the workers. As with the social bees and the social wasps, the workers are all modified females. With most ants the males and the queens are winged and the workers wingless; the wings of queens, however, are deciduous. In certain genera that live as parasites in the nests of other ants the worker caste is wanting, and in some species the females are wingless.

With many ants the polymorphism is not restricted to the presence of three uniform castes for one or more of the castes may be represented by more than one form. Of the males there may be either an unusually large form, or dwarfs, or ergatoid males, that is, males that resemble workers in having no wings and in the structure of the antennæ. The queens exhibit a similar series of forms; those of unusually large stature; dwarfs which are sometimes smaller than the largest workers; and ergatoid queens, which are a worker-like form, with ocelli, large eyes, and a thorax more or less like that of the normal queens, but without wings. In many species the workers are of two distinct sizes, the worker majors and the worker minors. In colonies that are founded by an isolated female the first brood of workers is of the worker minor form. With many species a worker form exists in which the head and the mandibles are very large, the soldier caste.

Although all ants are social, great differences exist among them as to the size of their colonies. In the more primitive species the fully developed colony consists of only a few dozen individuals with comparatively feeble caste development; while in the more highly specialized forms a colony may consist of hundreds of thousands of individuals and exhibit an elaborate polymorphism.

The different species of ants differ also in their nesting habits. By far the greater number of species excavate their nests in the ground. Certain species are often seen burrowing in paths or other open places; but many more are to be found under small flat stones or other objects lying on the ground. Some species, especially those in which the colonies become large, build large mounds of the excavated material. These mounds are very familiar objects in many parts of our country.

While most species of ants nest in the soil, there are many that build their nests in wood, in timbers, in the trunks of decaying trees, in or under bark, or in hollow stems. Others, especially certain tropical species, build in cavities of living plants; and still others, as *Crematogaster*, build carton nests.

A striking difference between the nests of ants and those of wasps and bees is that the ants do not construct permanent cells for their brood. The eggs, larvæ, and pupæ are stored in chambers of the nest and are moved from one to another in order to take advantage of the changes in temperature and moisture. Thus the brood may be brought near the surface of the nest during the warmer portion of the day and removed to deeper chambers at nightfall.

Large swarms of winged ants are often seen. These are composed of recently matured males and females that have emerged at the same time from many different nests, probably from all of the nests of the particular species involved that exist in the immediate region, and in which young queens and males have been developed. The object of these flights is mating, and they render probable the pairing of males and females from different nests, thus preventing too close interbreeding. The factors that determine the occurrence of the nuptial flights from all the nests of a species in one locality at the same time are not understood. In the case of those species in which the female is wingless the mating must take place either in the nest or on the ground outside.

After the pairing of the sexes the males soon die and each female proceeds to found a new colony if she is not captured by workers and taken into a colony already established or finds her own way into one. Except among the parasitic ants the method of founding a colony is as follows: The female breaks off her wings; then seeks out a small cavity under a stone or under bark or makes one in the ground. She closes the entrance to this cavity and remains isolated without food for weeks or months while the eggs in her ovaries are developing. During this period there is a histolysis of the large wing-muscles the products of which are used as food. When the eggs are mature they are laid and the larvæ that hatch from them are fed by the female, or queen as she is termed, with her saliva till they are ready to pupate. As the young queen takes no food during this period, the excretion fed to the larvæ must be derived from the fat in her body and the dissolved muscles. The adults that are developed from this first brood or larvæ are workers, but owing to the limited amount of food that they have received they are abnormally small; that is, of the form known as worker minors. These open the chamber in which they were developed and go forth to collect food for themselves and for the queen, and they take charge of the second brood of larvæ, which being supplied with abundant food develop into larger workers. The nest is now enlarged by the addition of new chambers and the growth of the colony continues. A few years later numerous males and females are developed, which at the proper time leave the nest for their nuptial flight.

The method of founding colonies described above is the usual one. But in some species the females have lost the power of establishing a colony unaided and must be adopted by workers of her own species or by workers of an alien species. The adoption of a queen by workers of an alien species explains the existence of some of the mixed colonies which are sometimes observed. The practice of slave-making described later, is the explanation of others. In certain parasitic species workers are wanting and the queens must find homes in nests of alien species.

The worker ants are so-called because upon this caste devolve all the labors of the colony after they appear on the scene in the foundation chamber. As a rule workers are sterile; but sometimes, as with bees, and wasps, fertile workers occur. It is believed that only males are developed from eggs laid by workers.

Without attempting to lead the beginning student through the maze of subfamilies, tribes, subgenera and subspecies into which the family of ants has been divided in an effort to classify the different forms, we shall simply discuss a few of the more common ants and some of those that have interesting and rather striking habits of living.

THE LEGIONARY OR VISITING ANTS

The members of this subfamily are largely confined to Equatorial Africa and tropical America. The colonies are nomadic, wandering from place to place in search of prey, and forming only temporary nests. Some of the species travel in vast armies and often overrun houses in the tropics, clear out the vermin with which they may be infested, and compel the human inhabitants to leave for a time.

The subfamily is represented in our fauna by a single genus, *Ĕciton*, species of which occur from North Carolina and Colorado southward. Our species, however, do not form large armies, though they hunt in files like the tropical species, and the colonies of some of the species may consist of thousands of individuals. Some of the species are fond of kidnapping the brood of other ants. The females are wingless and much larger than the workers. The workers are polymorphic.

THE MYRMICINE ANTS

In this subfamily the pedicel of the abdomen consists of two segments (Fig. 603). This is a large subfamily; more than half of the species of ants found in America north of Mexico belong to it. The following species will serve to illustrate the remarkable differences in habits of its different members.

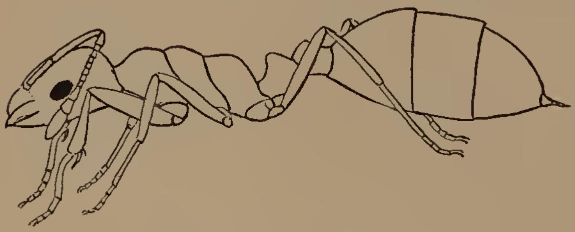

Fig. 603. — A myrmicid ant.

The little yellow house-ant, *Monomōrium pharaōnis*. — This is the species commonly known as the "little red ant" although it is light yellow in color. It is the most troublesome of all ants that invade our dwellings. It is only about one-sixteenth of an inch long and often occurs in great numbers. This ant will eat almost any household food but is especially fond of sweet substances. Its nests are often made within the walls of a house in which case it is nearly impossible to destroy them.

The harvesting ants. — Several genera of myrmicine ants feed on seeds, and as they collect these seeds and store them in their nests they are known as harvesting ants. It was to these ants that Solomon referred. They have also been known as agricultural ants; for it was formerly believed that they sow around their nests seeds of the plants from which they collect the grain that they use. But this has been disproved.

One of the characteristic harvesting ants of this country is *Pogonōmyrmex barbātus* and its subspecies. It occurs in Texas and is known as the " agricultural ant." It forms rather large colonies and its nest presents a bare, circular area from five to ten feet in diameter produced by destroying all of the plants around the central opening. The sting of this ant is as severe as that of the bumblebee and its bare areas in fields of alfalfa, corn, and cotton bring about considerable loss to the farmer.

The shed-builder ant, *Crematogăster lineolāta.* — In the tropics, ants belonging to several genera build carton nests attached to branches of trees. We have this one common species in the Northern States and Canada. This is a small ant, the workers measuring from $\frac{1}{8}$ to $\frac{1}{6}$ of an inch in length. It is usually yellowish-brown, with a black abdomen; but it varies greatly in color. Its favorite nesting-place is under stones or underneath and within the decayed matter of old logs and stumps. Out of this material the ants sometimes make a paper-like pulp with which they build a nest attached to the side of a log, or even to the branches of a shrub at some distance from the ground. While such nests are uncommon these ants often build small sheds at some distance from the nest, over the herds of aphids or coccids from which they obtain honey-dew (Fig. 604). In these cases the aphids or coccids are huddled together on a branch, from which they are deriving their nourishment, and are completely covered by the " cow-shed " built by the ants.

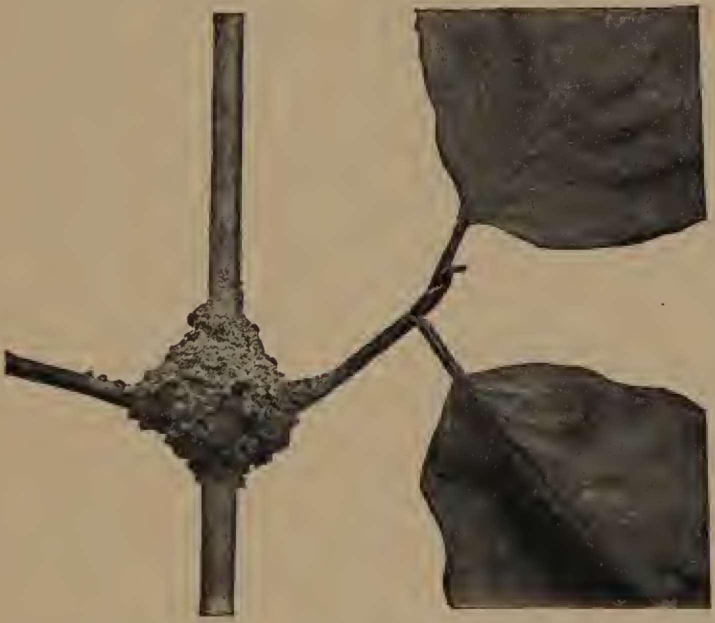

FIG. 604. — A "cow-shed" built by ants. (From A. B. Comstock, Handbook of Nature Study.)

THE FUNGUS-GROWING ANTS

Among the many remarkable examples of insect behavior none is more remarkable than the habits of the fungus-growing ants. These ants cut pieces of leaves from various plants and carry them to their nests where certain workers take them and chew them into fine bits which are then used as a medium on which to grow fungi as food for the members of the colony.

One common species, *Atta texāna*, occurs in central Texas. It is known as the parasol ant because files of the individuals may be seen, each with a piece of leaf held over its back like a tiny parasol, which it is carrying to its nest. This ant is often destructive to cotton, corn, fruit-trees and other plants for where it is abundant it will soon strip a plant of its leaves.

Most of the fungus-growing ants are confined to tropical and subtropical America but one species is found as far north as New Jersey.

THE ARGENTINE ANT AND ITS ALLIES

In this subfamily the pedicel of the abdomen consists of a single segment and there is no constriction between the first and second segments of the gaster. These ants often possess in addition to the poison glands, anal glands which excrete a foul smelling, sticky fluid, which is used as a means of defense in their combats with other ants.

Only about a dozen species have been described from our fauna and most of these are southern. Certain tropical species build carton nests attached to trees and some of our species make carton nests under stones. The members of this subfamily are especially fond of honey-dew and attend aphids and coccids to secure it. The most important species of the subfamily in our fauna is the following.

The Argentine ant, *Iridomȳrmex hūmilis.* — This is an introduced species, which has become an exceedingly serious pest in the Gulf States and in Southern California. Its injuries are of two kinds: first, as a household pest, entering and overrunning dwellings; and second, as an orchard pest. Its injuries in orchards are due to the fact that it protects aphids and coccids in order to secure the honey-dew that they excrete. The ants drive away the insect enemies of the aphids and coccids, which gives the latter a chance to multiply to an abnormal extent.

THE TYPICAL ANTS

The typical ants form a large subfamily containing many of our field ants and also those very interesting slave-making ants and the honey-ants. The pedicel of the abdomen consists of a single segment (Fig. 605). In this respect the typical ants are like the preceding subfamily.

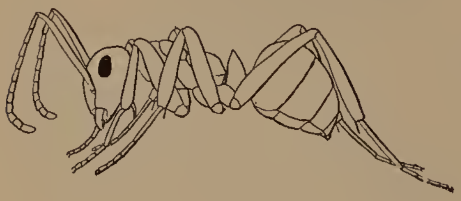

FIG. 605. — A typical ant.

The following are some of our more common species.

The carpenter ant, *Camponōtus herculeanus pennsylvānicus.* — This is one of the largest of our common ants. It is the large black species that builds its nests in the timbers of buildings, in logs and in the trunks of trees. Frequently it builds in the dead interior of a living tree, excavating a complicated series of chambers.

The mound-building ant, *Fŏrmica exsectoides.* — This species is the builder of our largest ant-hills; these are often three feet in height and six feet across, and sometimes they are much larger than this. New colonies are often formed by fission, a portion of the colony emigrating and founding a new colony with one or more queens. In this way many colonies are often established in a limited area. The head and thorax of this ant are rust-red, while the legs and abdomen are blackish-brown.

The blood-red slave-maker, *Fŏrmica sanguĭnea.* — More than a century ago Pierre Huber called attention to the fact that this species which is common in both Europe and America, keeps in its nests the workers of other species of *Formica*, which aid in performing the labors of the colony. The relations of the two species thus associated have been commonly regarded as that of slaveholders and slaves. The slaveholders obtain their slaves by making periodical forays on the colonies of the common black *Formica fusca*, and of other species of *Formica*, and bringing to their own nest the worker larvæ and pupæ. Some of these are eaten, but others are reared, and these knowing no other home take their place as active members of the colony.

In the blood-red slave-maker the gaster is black or brown and there is a notch in the margin of the clypeus. The nests of this species are low obscure mounds of earth or are excavated under stones or logs or around stumps. Many subspecies and varieties of this species are recognized, some of which do not keep slaves.

The shining amazon, *Polyĕrgus lūcidus.* — The species of the genus *Polyergus* were named amazons on account of their warring habits. Species of this genus occur in this country as well as in Europe. The shining amazon is a beautiful, brilliant red species widely distributed in the Eastern and Middle states. The species of this genus are slave-makers that have become absolutely dependent on their slaves. They cannot build their own nests or feed themselves or care for their young, but have only retained the power of fighting to get more slaves. Their mandibles are sickle-shaped and fitted only as weapons of offence. These ants also make periodical forays on the colonies of other species of *Formica* and carry home the worker larvæ and pupæ. The workers developed from these perform all of the labors of the colony except that they take no parts in the forays on the colonies of other ants. The young queens of *Polyergus*, being unable to work, establish new colonies of their species by securing adoption in some small weak colony of another species of *Formica* after killing its queen by piercing her head.

The corn-field ant, *Lāsius niger americānus.* — To the genus *Lasius* belong several common species of small brown ants that make small mounds in various situations. These ants are fond of honey-dew and not only care for the aphids from which they obtain it but collect the eggs of the aphids and store them in their nests through the winter, and in the spring place the recently hatched plant-lice on the stems and roots of the plants on which they feed. A well-known species of this genus is the corn-field ant which cares for the corn-root aphid and places it on the roots of corn in the spring.

The honey-ants, *Myrmecocȳstus.* — The ants of this genus are found in the arid regions of the Southwest, from the city of Mexico to Southern California and to Denver, Colorado. They have received the name of honey-ants from the remarkable fact that with them some of the workers function as honey-pots or reservoirs for storing the honey-dew collected by other workers, from nectar excreting galls on trees and from aphids and coccids. The individuals in which the honey-dew is stored are known as *repletes*. The workers that collect the honey-dew swallow it and carry it in their crop to the nest. There they regurgitate it and feed it to a replete, which in turn swallows it and retains it in its crop. The crop of the replete becomes so greatly distended that the gaster becomes a translucent sphere, as large as a pea, on the surface of which the sclerites appear as isolated patches separated by the tense, pellucid, yellowish, intersegmental membrane (Fig. 606). The repletes are unable to go about but remain quietly clinging to the roof of a chamber of the nest. When the season for obtaining honey-dew is passed, these living cells disgorge their supply through their mouths, for the use of the colony.

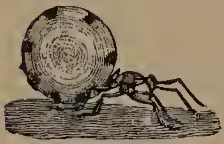

Fig. 606.

Family Vespidæ

The Typical Wasps or Diploptera

The family Vespidæ includes our most familiar wasps, the hornets, and the yellow-jackets, and their near allies. All members of this family are winged and nearly all of them when at rest fold their wings lengthwise like a fan; for this reason they are often termed the Diploptera or the diplopterous wasps. In the habit of folding their wings when at rest, the typical wasps differ from nearly all other Hymenoptera. The venation of a member of the Vespidæ is illustrated in Figure 607.

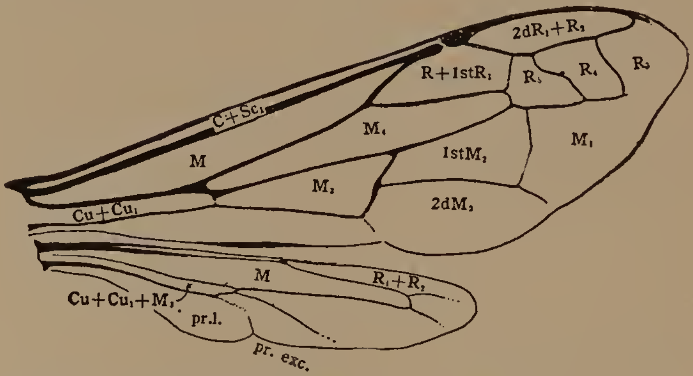

Fig. 607. — Wings of *Vespa diabolica*: *pr. l*, preanal lobe; *pr. exc.*, preaxillary excision. (From Bradley.)

If we take into account only the habits of these insects the subfamilies of the typical wasps can be separated into two groups, the *solitary wasps*, those in which a single female makes a nest for her young, and the *social wasps*, in which many individuals work together to make a nest. This grouping of the subfamilies, however, is not regarded as a natural division of the family Vespidæ, but this grouping is useful in a discussion of the habits of these insects.

THE SOLITARY VESPID WASPS

Most of our species of the solitary vespid wasps belong to the group known as the *eumenids*. The females of these wasps work alone, each one building its own series of cells in each of which is placed an egg together with provision for the young. The cell is then closed and probably forgotten by the mother wasp. An African eumenid wasp has been observed, however, which does not gather provision in advance but leaves the cell open and feeds the larva from day to day.

The different species of eumenids differ greatly in methods of nest-building; many are miners digging burrows in the earth leading to cells in which provisions are placed for their young; some make burrows in wood, which they divide into cells by partitions of mud; some build their nests in the stems of pithy plants or make use of any suitable cavity that they find; and others are mason or potter-wasps, making cells of earth, which are built in holes, or on the surface of the ground, or attached to twigs.

Although the adult eumenids do not confine themselves to a carnivorous diet but often visit flowers to obtain nectar, they all provision their nests with insects, which they have paralyzed with their sting; usually only a single species of caterpillar is used for this purpose by each wasp.

Odynērus. — The greater number of our species of eumenids belong to the genus *Odynērus*. In this genus the abdomen is sessile. The shape of the body and frequently the coloration resemble those of the social wasps known as yellow-jackets, although usually the body is more slender and smaller. The common species are quite neighborly; and, owing to this resemblance to the yellow-jackets they inspire us with a fear that is out of all proportion to their will or ability to inflict pain.

Many species of *Odynerus* are miners. Their burrows are to be found both in level ground and in the sides of cliffs. Branching from these burrows are short passages, each leading to a cell, from the ceiling of which an egg is suspended by a slender thread; and in which food is stored for the larva. In the species that have been studied, this food consists of small, paralyzed caterpillars. Some of the mining species while digging the burrow build a turret over the entrance of it, made of pellets of mud removed from the burrow (Fig. 608). The material of which the turret is composed is used to fill up the burrow after the cells are finished. In digging the burrow and in tearing down the turret the earth is softened with water, which the wasp brings in her mouth from some pool or stream.

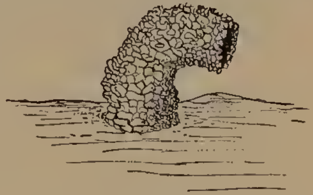

FIG. 608. — Turret over the burrow of *Odynerus geminus*. (After Rau and Rau.)

Not all species of *Odynerus* mine in the ground; many burrow in the stems of pithy plants, making a series of cells separated by partitions of mud; other species will avail themselves of any convenient cavity in which to make their nest, frequently utilizing the deserted nests of the sphecoid-wasps known as mud-daubers. In this case a single cell of a mud-dauber is divided by a transverse partition, making two cells for the smaller *Odynerus*. One year these wasps plastered up many of the key-holes in our house, including those in bureaus.

The jug-builders, *Eūmenes*.— The wasps of the typical genus of this subfamily are potter-wasps which build nests that appear like miniature water-jugs. The nests of our common species, *Eūmenes fratĕrnus*, are often found attached to twigs (Fig. 609). In this genus the abdomen of the adult is petiolate. These wasps provision their nests with caterpillars and frequently with cankerworms.

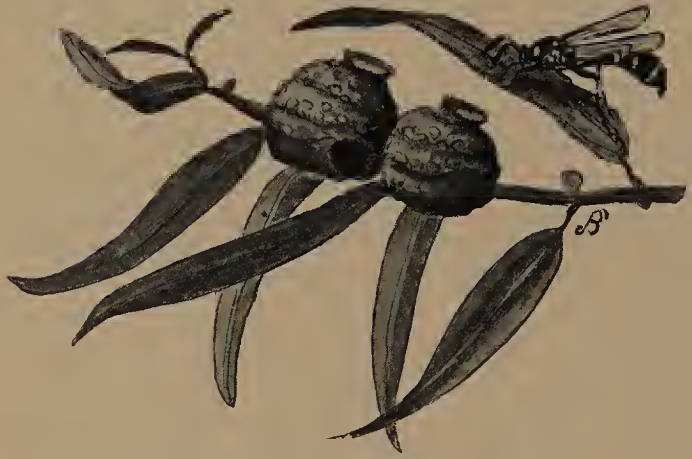

Fig. 609. — *Eumenes fraternus* and its nests.

Fabre, who studied the habits of a European species of *Eumenes* observed what goes on within the nest by making a window in the side of it. The egg is suspended from the ceiling of the nest by a slender thread; when the larva hatches, it at first makes use of the egg-shell as its habitation and stretches down to feed on the caterpillar below it; if disturbed it retreats up its support. Later when the larva has increased in size and strength it descends to the mass of food.

Monōbia quădridens. — This species (Fig. 610) is common in most of the states east of the Mississippi. It is larger than the jug-builders, and the abdomen of the adult is sessile. Figure 611 represents a nest of this species, now in the Cornell University collection, which was made in a board in the side of a barn. The partitions are made of mud. Each cell contained a pupa when the nest was opened, hence it was not evident what the food of the larvæ had been; but several observers state that this species stores its nests with large cutworms; and it is doubted that this species is a carpenter-wasp. It seems probable that the nest figured here was made in a deserted burrow of the large carpenter-bee, *Xylocopa virginica.* It differs from a nest of this bee only in that the partitions are made of mud.

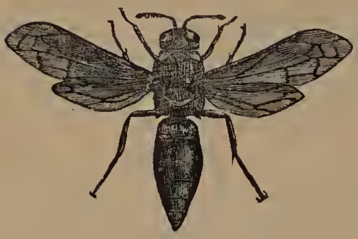

Fig. 610. — *Monobia quadridens.*

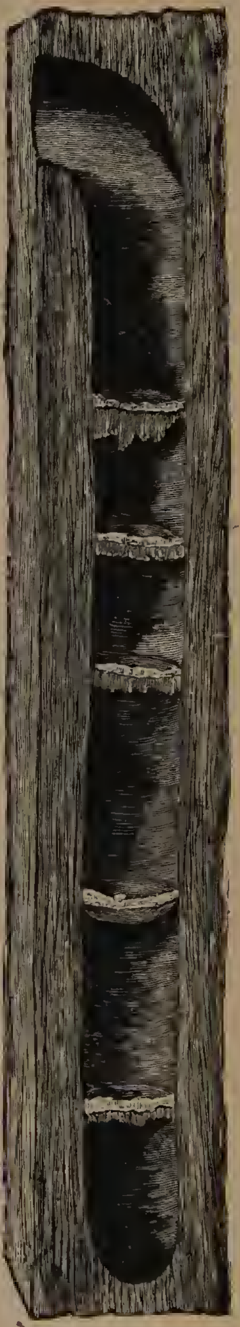

Fig. 611. — Nest of *Monobia quadridens.*

THE SOCIAL VESPID WASPS

Since these are the only wasps that are social they are commonly referred to as the social wasps instead of by the more technical name.

As with the ants the colonies of social wasps consist of three castes, the female or queen, the workers, and during the later part of the season, the males. The workers are females in which the reproductive organs are imperfectly developed.

In the temperate regions the colonies exist for only one season; the males and the workers die in the autumn; the females hibernate and each starts a new colony in the spring. At first the female performs the functions of both worker and queen, starting the building of the nest and laying the eggs. In the early part of the season only workers are developed; after they appear they carry on the labors of the colony, expanding the nest and procuring the food for the larvæ; the only function of the queen then is to produce the eggs. In the later part of the season males and females are developed.

The social wasps are predacious, and they feed their larvæ upon insects which they have malaxated. The wasps are also fond of the sweets of flowers, the juices of fruits, and of honey-dew.

In the temperate regions the multiplication of colonies is brought about by the production of many males and females in the nest in the later part of the season; these pair, the females hibernate, and each female founds a new colony in the spring. But in the Tropics certain species form large perennial colonies, which from time to time give off swarms, in a way quite similar to the well-known swarming of the honey-bee.

The Social Polistes. — The wasps of the genus *Polistes* and their nests are very familiar objects. The nests consist each of a single horizontal comb suspended by a peduncle, and the comb is not enclosed in an envelope (Fig. 612). These nests are often built under the eaves of buildings, in garrets, and in sheds and barns; they are also often made under flat stones in fields, and sometimes attached to bushes.

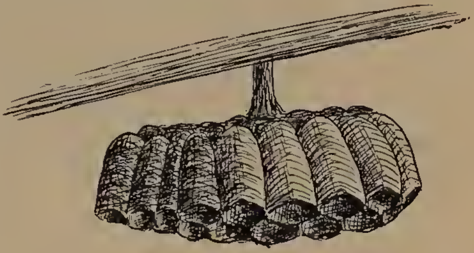

Fig. 612. — Nest of *Polistes*.

The nests are made of a grayish paper-like material, composed of fibers of weather-worn wood, which the wasps collect from the sides of unpainted buildings, fences, and other places, and convert into a paste by the action of the jaws and the addition of some fluid, probably an oral secretion. The nests of *Polistes* are usually comparatively small; but some have been found in Texas that measured more than a foot in diameter.

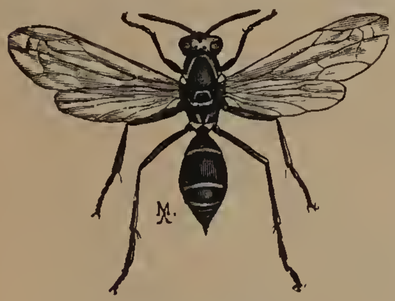

Fig. 613. — *Polistes*.

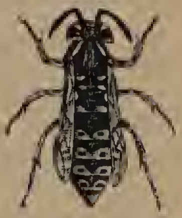

Fig. 614. — *Vespa*.

In this genus the abdomen is long and spindle-shaped (Fig. 613).

Several of the species are known to store small quantities of honey in their combs.

These wasps are often infested by stylopids.

The Social Hornets and Yellow-jackets. — This subfamily includes those wasps that are commonly known as hornets and the yellow-jackets. With these insects the body is comparatively short and rather stout (Fig. 614); the abdomen is attached to the thorax by a very short pedicel; and the color is black, spotted and banded with yellow or yellowish-white. The members of this subfamily differ from other vespoid wasps in that the hind wings are without an anal lobe (Fig. 607).

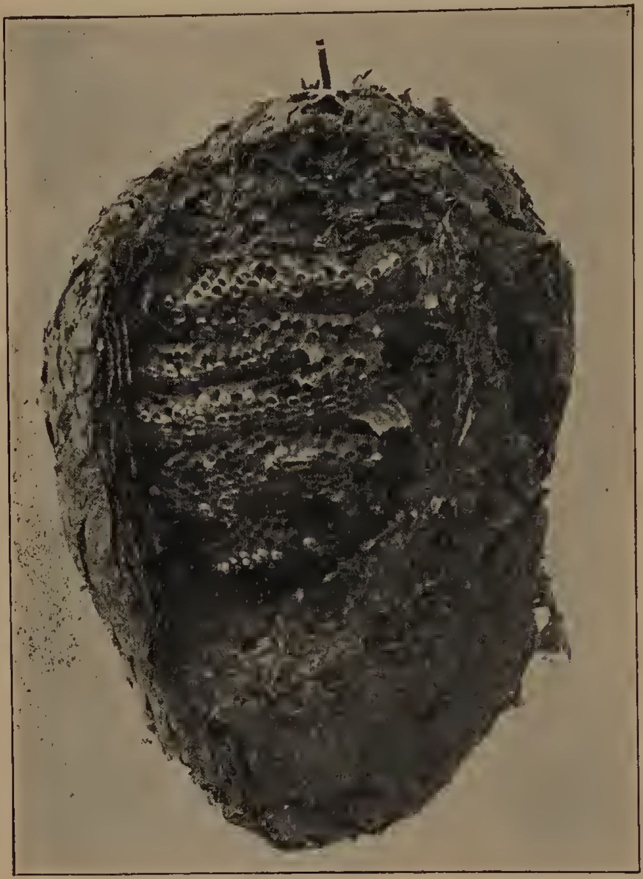

FIG. 615. — Nest of *Vespa*, with side removed. (From A. B. Comstock, Handbook of Nature Study.)

These wasps make their nests of paper, which in some cases is composed of fibers of weather-worn wood, like that of *Polistes* described above, in other cases of fragments of more or less decayed wood. These nests consist of a series of horizontal combs suspended one below another and all enclosed in a paper envelope (Fig. 615).

When the wasps wish to enlarge their nest they remove the inner layers of the envelope, and add to the sides of the combs, build additional combs below, and put on new layers on the outside of the envelope. By these additions the nest may become of large size by the end of the season.

Very small empty nests consisting of a single comb with but few cells and enclosed in an envelope of only one or two layers of paper are often found (Fig. 616). Such a nest is evidence of a tragedy. A queen wasp, in the spring, had started to found a colony. It was necessary for her to go back and forth in the fields collecting material for her nest and food for her larvæ; and before a brood of workers were developed to relieve her of this dangerous occupation she became the prey of an enemy and the development of the colony was wrecked.

Two quite different types of nests are made by different species of these wasps, and these are made in quite different situations. One kind is built above ground; these are attached to bushes or trees, or beneath the eaves of buildings; they are

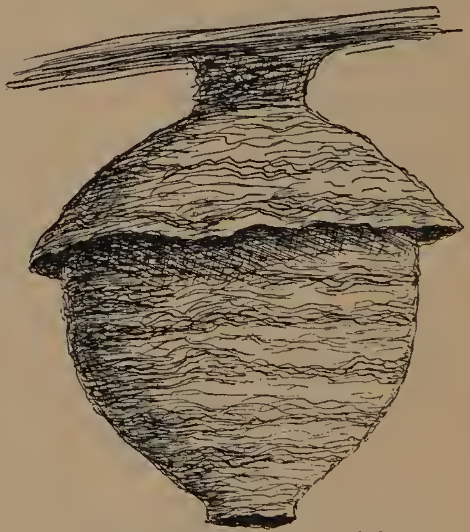

FIG. 616. — Early stage of nest of *Vespa*.

made of a grayish paper composed of fibers of weather-worn but not decayed wood. This paper is comparatively strong, so that the envelope of the nest is composed of sheets of paper of considerable size, a single sheet often completely enveloping the nest. The wasps which build this type of nest are commonly known as hornets.

The other kind of nest is built in a hole in the ground, which is enlarged by the wasps as they need more room for the expansion of the nest. The paper of which these nests are made is brownish in color and is made out of partially decayed wood; it is very fragile and would not be suitable, therefore, for use in nests built in exposed places. Even though the nest is built in a protected place, the use of this fragile material necessitates a different style of architecture. The enveloping layer of the nest, instead of being composed of sheets of considerable size, are made up of small, overlapping, shell-like portions, each firmly joined by its edges to the underlying parts. The wasps which build these underground nests are commonly known as yellow-jackets.

It has been found that at least two species of this subfamily are social parasites. In these species the worker caste has been lost, there being only males and females. The female enters the nest of another species of *Vespa* and lays her eggs, and her larvæ are reared by the rightful owners of the nest.

The members of the social hornets and yellow-jackets found within the limits of our territory are commonly included in a single genus, *Vespa*. Only a few of our species can be mentioned here.

The giant hornet, *Vĕspa crābro.* — This is our largest species, measuring about ¾ of an inch in length. It is brown and yellow in color and is found around New York City, on Long Island, and in Connecticut. It builds its nests in hollow trees and within buildings suspended from the roof. It came to this country from Europe.

The white-faced hornet, *Vĕspa maculāta.* — This is the common, large black and white hornet. It is widely distributed in the United States and Canada. The nest, which is sometimes very large, is usually attached to the limb of a tree.

A common yellow-jacket, *Vespa maculifrons.* — This is one of the common species that builds its brown paper nests in the ground or beneath some object on the ground or, occasionally, in a stump. In the height of the season there may be several hundred individuals in a nest which they will defend against an intruder with wild fury. Another common yellow-jacket is *V. diabolica* with similar nesting habits but which also, at times, builds aerial nests.

THE DIGGER-WASPS OR SPHECOID WASPS.

The wasps in this group are perhaps more properly known as sphecoid wasps but since most of them make nests for their young by burrowing in the ground or in wood they may very properly be called digger-wasps. There are three families in the group of which the first, Ampulicidæ, is small and its members rare; the second, Dryinidæ, is composed of parasitic forms; and the third, Sphecidæ, is a large one and contains many species of varied habits.

Family DRYINIDÆ

The Dryinids

This family is composed of small parasitic wasps of remarkable habits; it is widely distributed over the world and is represented in our fauna by many genera.

The fore wings have a lanceolate or ovate stigma; the hind wings are without closed cells; the antennæ consist of ten segments, the anterior tarsi of the female are usually chelate. The females of the genus *Gonăto-pus* are wingless, ant-like, and are without a scutellum.

These parasites confine their attacks to the homopterous insects belonging principally to the families, Fulgoridæ, Membracidæ, and Cicadellidæ.

The female dryinid seizes her victim with her raptorial fore legs; one pair of pincers usually grips the neck of the prey, the other pair grips the abdomen towards the apex or the hind legs. The wasp then inserts her egg into the body of the bug. A few days later the immature larva of the parasite appears outside the body of its host enclosed in a sac composed of molted skins. Here it remains, with its head in the opening in the body-wall of its host, until it has completed its growth. It then leaves its host and spins a silken cocoon, which in some cases is furnished with an outer covering formed of the larval sac or of round patches of epidermis stripped off from the leaf surface.

Family SPHECIDÆ

The Typical Sphecoid Wasps

In this family the hind wings have an anal lobe and some closed cells; the abdomen of the male has seven exposed tergites. All members of the Sphecidæ are winged.

To this family belong all of our common nest-building sphecoid wasps. These differ from the bees in that they provision their nests with animal food, insects or spiders, which they have paralyzed by stinging them. Different members of the family differ greatly in their nesting habits; some are mason-wasps, building cells of earth; many burrow in the ground; and others burrow in the stalks of pithy plants or make use of cavities that they find.

Most members of the Sphecidæ, after preparing their nest, rapidly accumulate an amount of prey sufficient to enable the young to develop to maturity, lay an egg with it, and then close the cell before the egg has hatched. This method is termed *mass provisioning*. But certain members of the family, *Bembex*, and some others, feed their young from day to day as long as they remain in the larval state. This method is termed *progressive provisioning*. As each larva requires constant attention for a considerable time only a few young can be reared by a single female in this way.

Many of these wasps after stinging their prey and before placing it in their nest malaxate (*i.e.*, chew) its neck or some other part of the body and lap up the exuding juices.

Only a few of the more common members of the family can be discussed here although they are among the most interesting of the Hymenoptera because of their remarkable nesting habits.

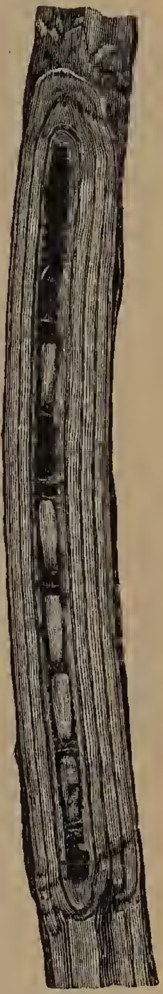

FIG. 617.—Nest of *Trypoxylon frigidum.*

Wasps of the genus *Trypŏxylon.* — These are black slender wasps of medium size one of which, *T. frĭgidum*, makes its nests here in New York, very commonly in the branches of sumac (Fig. 617). The cells of these nests are separated by partitions of mud and are stored with spiders.

Mr. and Mrs. Peckham who studied two other species, *T. albopilōsum* and *T. rubrocĭnctum*, in Wisconsin give a very interesting account of the coöperation of the males and females during the nest-building period as follows:

" With both species when the preliminary work of clearing the nest and erecting the inner partition has been performed by the female, the male takes up his station inside the cell, facing outward, his little head just filling the opening. Here he stands on guard for the greater part of the time until the nest is provisioned and sealed up, occasionally varying the monotony of his task by a short flight." " We have frequently seen him drive away the brilliant green *Chrysis* fly which is always waiting about for a chance to enter an unguarded nest." " In one instance, with *rubrocinctum* where the work of storing the nest had been delayed by rainy weather, we saw the male assisting by taking the spiders from the female as she brought them and packing them into the nest, leaving her free to hunt for more."

Some species of *Trypoxylon* are mud-daubers. *Trypoxylon albitarsis*, a shiny black species with white tarsi, builds large nests of mud, which consist of several parallel tubes, often three inches or more in length, placed side by side. These nests are known as pipe-organ nests. Each tube is divided by transverse partitions into several cells, which are provisioned with spiders. The tubes when completed are not covered with an extra layer of mud as is commonly the case in the nests of other mud-daubers. When an adult is ready to emerge from the cell in which it was developed, it makes a hole through the exposed side of the tube.

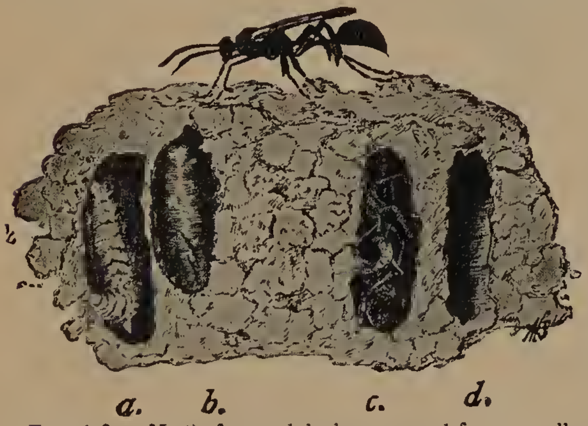

FIG. 618. — Nest of a mud-dauber removed from a wall exposing the cells: *a*, larva full-grown; *b*, cocoon, *c*, young larva feeding on its spider-meat; *d*, an empty cell. (From A. B. Comstock, Handbook of Nature Study.)

The thread-waisted wasps.— These are the most commonly observed of all of our sphecoid wasps, as certain species build their mud nests in the attics of our houses; and, too, the peculiar shape of the body makes them very conspicuous. Most of the species burrow in the ground and store their nests either with caterpillars or with Orthoptera. But those best known to us are the mud-daubers.

The mud-daubers make nests of mud attached to the lower surface of flat stones or to the ceilings or walls of buildings. These nests usually consist of several tubes about one and one-fifth inches in length placed side by side (Fig. 618) and are provisioned with spiders. The mud-daubers may be seen in damp places collecting mud for their nests, or exploring buildings in search of a place to build. They have a curious habit of jerking their wings frequently in a nervous manner. There are in this country two widely distributed and common species of mud-daubers; these are the blue mud-dauber, *Chalÿbion cærulium*, which is steel blue with blue wings, and the yellow mud-dauber, *Scĕliphron cementārium*, which is black or brown with yellow spots and legs (Fig. 619). The latter of these species has been commonly described under the generic name *Pelopæus*.

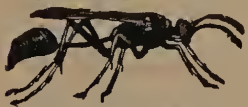

Fig. 619. — *Sceliphron cementarium.*

The tool-using wasps, *Ammŏphila.* — Among the members of the sphecoid wasps that burrow in the ground and store their nests with caterpillars are certain species of the genus *Ammŏphila*. These are of especial interest on account of the habit first observed by the Peckhams, of pounding down the earth with which they close their burrow by taking a stone or some other object in their mandibles and using it as a hammer.

The genus *Chlōrion*, formerly known as *Sphex*, includes species which are among the most common of flower visitors in the warmer parts of our country, and are among the largest and most handsome, and therefore most often observed of our wasps. In the West the common, very large, all metallic green, *Chlōrion cyāneum*, is a very striking insect; and in the East, *Chlorion ichneumōneum*, which is brownish-red with the end of the abdomen black, is the most noticeable.

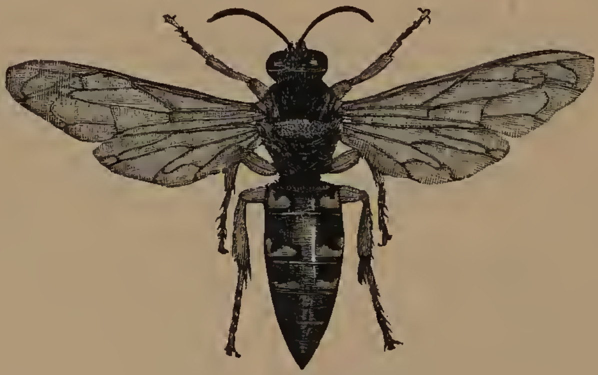

Fig. 620. — *Sphecius speciosus.*

The cicada-killer, *Sphēcius speciōsus*.- This is a large handsome wasp about 1⅕ inches in length (Fig. 620). It is black sometimes of a rusty color, and has the abdomen banded with yellow. It is particularly abundant in July from New Jersey southward. It digs its burrows usually in the drier situations and stores at the bottom in enlarged cells one or more cicadas. The wasp locates a cicada in a tree, suddenly stings it, thus paralyzing it when both fall to the ground. The wasp then laboriously drags the cicada to its burrow, perhaps flying part of the way, the whole operation often taking an hour or more. When the cicada is finally stowed away at the bottom of the burrow the wasp lays an egg on its body where it hatches and the young wasp larva feeds on the paralyzed victim.

Wasps of the genus *Bembex.* — These are stout-bodied wasps, usually black with greenish or greenish-yellow bands. They burrow in the sand and provision their nests with flies. Some species at least practise progressive provisioning. After excavating its burrow and making a cell, the wasp captures a fly and stings it to death, then places it on the floor of the cell and attaches an egg to it. After the larva has hatched, the mother collects flies from day to day, feeding the larva till it is ready to change to a pupa, closing the nest behind her each time she leaves it.

A common and well-known related wasp in the South is *Sticta carolina* which is called the " horse guard." This is a large species which hunts about horses in order to capture flies.

THE BEES

The bees constitute a very large group of insects, including besides the well-known honey-bee and the bumblebees thousands of other species, many of which can be observed visiting flowers on any pleasant summer day. An authority states that 12,000 species of bees have been described, of which 2,500 are from North America and estimates that there are 20,000 living species in the world.

The bees differ from all other Hymenoptera, except a few vespoid wasps, in that they provision their nest with pollen and honey instead of with animal food, as do other nest-building Hymenoptera. The honey is obtained from flowers in the form of nectar, which is swallowed and transported to the nest in the crop. While in the crop the nectar undergoes a chemical change, which is probably due to a mixture with it of a ferment derived from the salivary glands, and becomes what is known as honey.

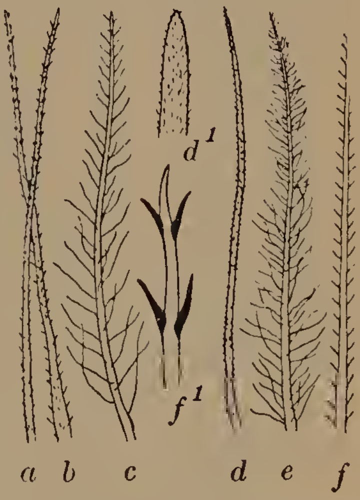

FIG. 621. — Hairs of bumblebees. (After John B. Smith.)

A characteristic of bees found in only a few other Hymenoptera is the presence, especially on the thorax, of plumose hairs. Many forms of these hairs exist; some of them are represented in Figure 621. It has been suggested that the plumose hairs serve to hold the grains of pollen that become entangled among them when a bee visits a flower; but they occur in males and in parasitic bees neither of which gather pollen; they are lacking, however, in some parasitic bees.

Female bees, excepting those of the genus *Prosopis* and of the parasitic bees, are furnished with pollen-brushes or *scopæ*, for collecting and transporting pollen. In most bees these consist of brushes of hairs borne by the hind legs, but in the Megachilidæ the brush is on the ventral side of the abdomen:

In some bees the pollen brushes are restricted to the tibia and the metatarsus of the hind legs, in others they are borne on these two segments and on the femur, trochanter and coxa as well (Fig. 622). With the queens and workers of the nest-building bumblebees and with the workers of the honey-bee the pollen-carrying apparatus is very highly

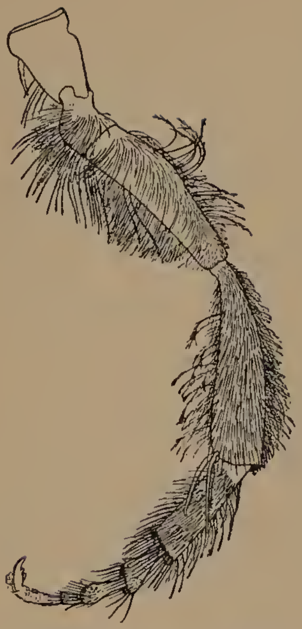

Fig. 622. — Hind leg of female of *Colletes* with brushes on all segments. (From Brane.)

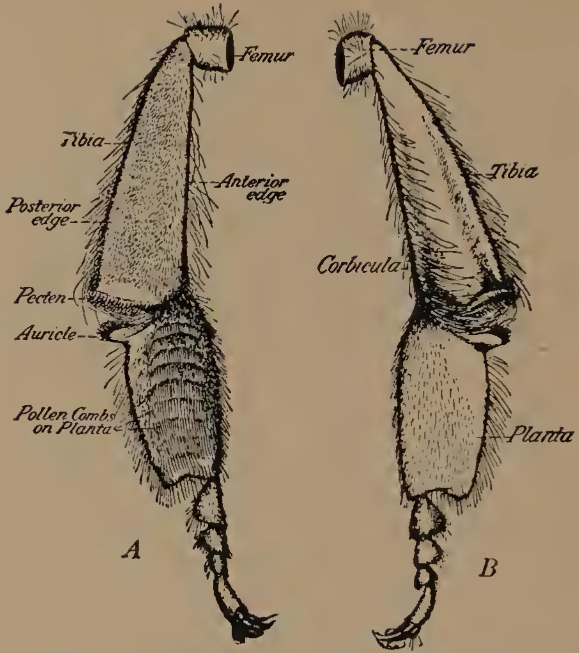

Fig. 623. — A. Inner surface of the left hind leg of a worker honey-bee; B. Outer surface of the same. (After D. B. Casteel.)

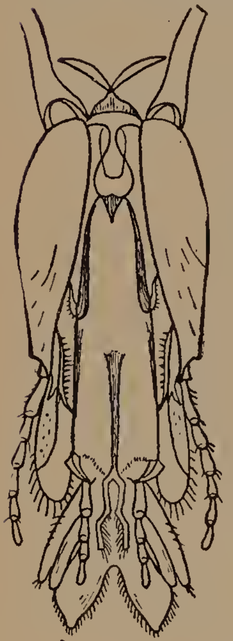

Fig. 624. — Proboscis of *Colletes*. (After Saunders.)

specialized (Fig. 623). On the outer surface of the tibia of the hind legs there is a smooth area which is margined on each side by a fringe of long curved hairs; this structure is known as the pollen basket or *corbĭcula;* and on the inner surface of the metatarsus, termed *planta* by some writers, there is a brush of stiff hairs by means of which the bee gathers the pollen from its body. In the honey-bee the hairs composing this brush are arranged in transverse rows and are termed the pollen combs.

The mouth-parts differ greatly in form in the different groups of bees; this is especially true of the maxillæ and labium, which together constitute the proboscis, used for extracting nectar from flowers. The mandibles are fitted for chewing and do not vary so much in form.

In the most generalized bees, the proboscis is comparatively short and the labium is either notched at the tip, or is quite deeply bifid (Fig. 624). In all other bees the labium is pointed at the tip. Among the bees with a pointed labium the proboscis varies greatly in length; in some it is comparatively short, while in the more specialized forms (Fig. 625) it is greatly elongate.

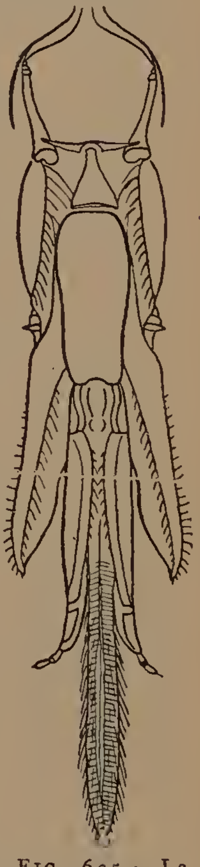

Fig. 625. — Labium of the honey-bee. (After Saunders.)

The two sexes of bees differ in the number of abdominal tergites exposed to view; in the male there are seven, in the female, only six.

The different species of bees exhibit great differences in habits; some are solitary, each female providing a nest for her young; some are parasitic, the females laying their eggs in the nests of other bees and the larvæ feeding on the provisions stored by their hosts; and some are social, living in colonies consisting of many individuals.

The nests of solitary bees, like those of the digger-wasps, are of many forms. The mining-bees dig tunnels in the ground; the mason-bees build nests of mortar-like material; the carpenter-bees make tunnels in the stems of pithy plants or bore in solid wood; and some bees make nests of comminuted vegetable matter. The distinctive characteristic of the nests of bees is the fact that they are always provisioned with honey and pollen. In many cases closely allied species of bees differ in their nesting habits; for example, different species of the genus *Osmia* build very different kinds of nests.

The social bees are the honey-bees, the bumblebees, and the stingless honey-bees of the Tropics. In all of these, as with the social wasps and the ants, there is in addition to the males and the egg-laying females a worker caste; with all other bees there are only two forms, the males and the females.

Family Andrenidæ

The Andrenids

The family includes those solitary nest-building bees and their parasitic allies in which the tongue is either short or long but is pointed at the apex, and in which the pollen-brushes of the nest-building females are borne by the hind legs. To this family belong a large portion of the species and genera of our bees. Space can be taken here to discuss only a few of these.

Halictus. — Among the more common of our mining bees are those of the genus *Halictus*. This is a large genus including very many species, among which are the smallest of our bees. The nests of some species are excavated in level ground; other species dig tunnels in the vertical sides of banks. These bees are often gregarious, hundreds of nests being built near together in the side of a bank.

If these nests be studied in midsummer, each will be found to consist of a burrow extending into the bank and, along the sides of this main burrow or corridor, smaller short burrows each leading to a cell, the sides of which are lined with a thin coating of firm clay (Fig. 626). In each of

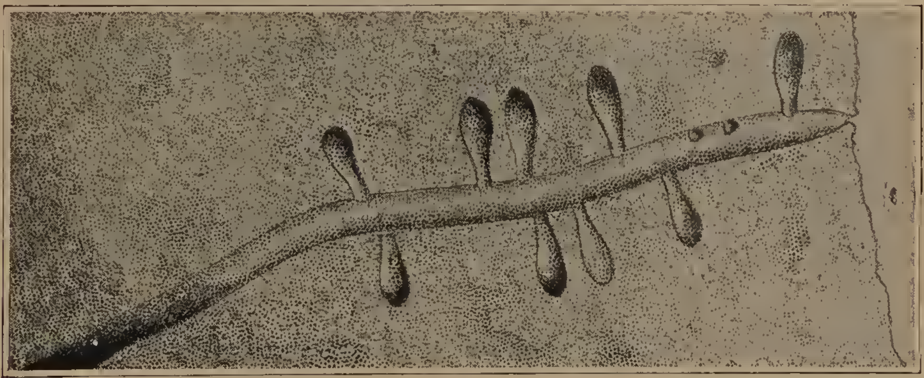

Fig. 626. — Diagram of part of a nest of *Halictus*.

these cells that is closed will be found either a mass of pollen and nectar with an egg upon it or a larva feeding on the food stored for it.

The most striking feature of these nests is the fact that several bees use the corridor as a passage-way to the cells they are building and provisioning. But this corridor is not a public one; it is constricted at its outer end and is guarded by a sentinel whose head nearly fills the opening. When a bee comes that has a right to enter, the sentinel backs into the wider part of the corridor and allows it to pass and immediately thereafter resumes its guarding position with its head closing the opening of the corridor.

Anthŏphora. — The genus *Anthophora* is widely distributed and includes many species, more than eighty have been described from North America alone; but the habits of only a few of these have been described.

The nests of those American species the habits of which are well known are usually built in steeply inclined or perpendicular banks of earth, preferably in those of compact clay; they are also excavated in the clumps of clay held between the roots of stumps in stump-fences. In the West a favorite nesting place of these bees is in the walls of sun-dried bricks of the adobe houses. Like *Halictus* and *Andrena*, the bees of this genus are gregarious, hundreds of individuals building their nests close together in the same bank of earth.

A striking feature of these nests is the presence of a cylindrical tube of clay extending outward and downward from the entrance of the tunnel. This tube is rough on the outside but smooth within. It is composed of small pellets of earth compacted together. These pellets when brought out from the tunnel are wet and easily molded into the desired form, but soon become dry and firm (Fig. 627).

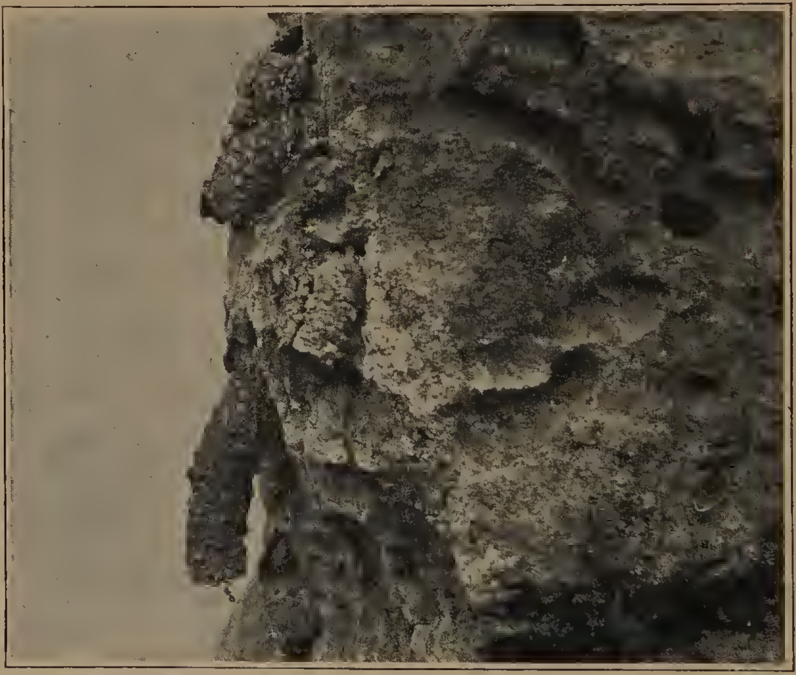

FIG. 627. — Section of a bank with nests of *Anthophora*. (Photographed by Miss P. B. Fletcher.)

Andrēna. — Among the larger of our common mining bees are certain species of the genus *Andrena;* some of these nearly or quite equal in size the workers of the honey-bee. They build their nests in road sides and in fields that support a scanty vegetation. They sink a vertical shaft with broad cells branching from it. These bees, though strictly solitary, each female building her own nest, frequently build their nests near together forming large villages. We once received from a correspondent a description of a collection of nests of this kind which was fifteen feet in diameter, and in the destruction of which about two thousand bees were killed; what a terrible slaughter of innocent creatures!

The small carpenter-bee, *Cerătina dūpla.* — The nests of this bee are built in dead twigs or sumac and in the hollows of brambles and other plants. They are more common than those of any other of our solitary bees that build in these situations. This is a dainty little bee, about $\frac{1}{4}$ of an inch in length, and of a metallic blue color. She always selects a twig with a soft pith which she excavates with her mandibles, and so makes a long tunnel. Then she gathers pollen and nectar and puts it in the bottom of the nest, lays an egg on it, and then makes a partition out of pith-chips, which serves as a roof to this cell and a floor to the one above it. This process she repeats until the tunnel is nearly full, then she rests in the space above the last cell, and waits for her young to grow up. The lower one hatches first; and after it has attained its growth it tears down the partition above it, and then waits patiently for the one above to do the same. Finally after the last one in the top cell has matured, the mother leads forth her full-fledged family in a flight in the sunshine. After the last of the brood has emerged from its cell, the substance of which the partitions were made, and which has been forced to the bottom of the nest by the young bees when making their escape, is cleaned out by the family, the old bee and the young ones all working together. Then the nest (Fig. 628) is used again by one of the bees.

The large carpenter-bee, *Xylŏcopa virgĭnica.* — This is a large insect, measuring from about an inch in length and resembling a bumblebee in size, and somewhat in appearance. But it can be easily distinguished from a bumblebee, as the female has a dense brush of hairs on the hind leg, instead of a basket for carrying pollen. This bee builds its nest in solid wood, and sometimes excavates a tunnel a foot in length, which it divides into several cells. The partitions between the cells are made of chips of wood, securely cemented together, and arranged in a closely wound spiral. This arrangement of chips is easily seen when the lower side of a partition is examined; but the upper side of a partition which forms the floor of the cell above it is made concave and very smooth, so that the arrangement of the chips is not visible.

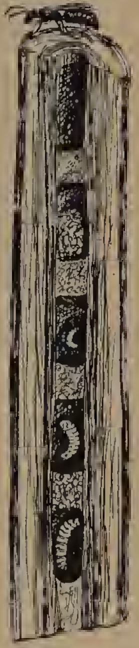

Fig. 628. — Nest of *Ceratina dupla.*

Family Megachilidæ

The Leaf-cutter Bees and their Allies

To this family belong those bees in which the pollen brush of the female is borne on the ventral side of the abdomen and the parasitic bees that are allied to them. In this family the tongue is long and there are only two submarginal cells of approximately equal size in the fore wings. Among the better-known representatives of the family are the following.

The leaf-cutter bees, *Megachīle.* — The bees of the genus *Megachile* have a curious habit of making cells for their young out of neatly-cut pieces of leaves. These cells are packed away in such secure places that one does not often find them; but it is a very easy thing to find fragments of leaves from which the pieces have been cut by bees. The leaves of various plants are used for this purpose, but rose-leaves are used more frequently than any other kind. In Figure 629 there are represented one of these bees, its nest, and a spray of rose-leaves from which pieces have been cut by the bee.

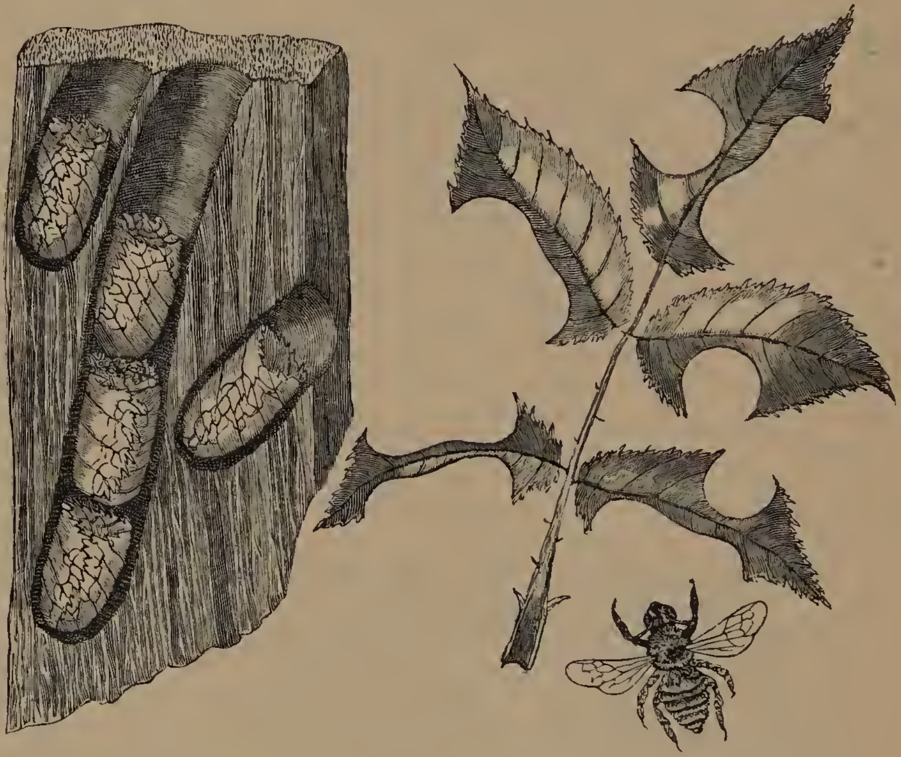

Fig. 629. — A leaf-cutter bee, *Megachīle latimanus*, its nest, and rose-leaves cut by the bee.

The nests are made in various situations. The specimen figured was taken from a piece of hemlock timber in which many of these bees had bored tunnels to receive their cells. We have also found nests of these bees in a tunnel in the ground under a stone, between shingles on a roof, in the cavity of a large branch of sumac, in the cavity of a lead pipe, and in Florida in the tubular leaves of a pitcher-plant.

When a suitable tunnel has been made or found the bee proceeds to build a thimble-shaped tube at the bottom of it. For this purpose it cuts from leaves oblong pieces, each of which forms a part of a side and the bottom of the thimble-shaped tube. Two such pieces had been cut from the lower leaf on the left side of the spray figured here. When the thimble-shaped tube is completed, the bee partially fills it with a paste of pollen and honey, and then places an egg upon the supply of food. She then cuts several circular pieces of leaves, the diameter of which is a little greater than the diameter of the tube, and forces them into the open end of it, thus making a tightly fitting plug; three of these circular pieces have been cut from the spray figured. Usually several cells of this kind are placed end to end in a burrow; and sometimes many bees will build their nests near together in the same piece of wood.

Family Bombidæ

The Bumblebees

The family Bombidæ includes the well-known nest-building bumblebees and certain parasitic bumblebees, *Psĭthyrus*, that infest the nests of the nest-building species. The members of this family are large bees or of medium size; they are robust with oblong bodies and a rather dense covering of hair. They are common, and are conspicuous on account of their noisy flight and striking coloration, which is usually yellow and black. They are called bumblebees on account of the sound they make in flight; in England they are commonly known as humblebees.

The nest-building bumblebees, *Bŏmbus*. — The members of this genus are social insects, each species consisting as in other social insects of three castes, the queens, the workers, and the males. In this genus the queens as well as the workers possess pollen-baskets or corbiculæ on the hind legs; as the queen when founding a colony must collect pollen.

With the bumblebees the queens are larger than either the workers or the males and, in temperate regions, are the only ones that live through the winter; as in these regions the colonies, like those of our northern species of social wasps, break up in the autumn and all of the bees, except the young queens perish. These crawl away into some protected place and pass the winter. In the spring each queen that has survived the winter founds a new colony, performing, until a brood of workers has been developed, both the duties of queen and of worker. In South America, where according to von Ihering, bumblebee colonies are perennial, new nests are formed by swarming as among the social wasps of the same region.

In selecting a place for her nest the queen usually chooses a deserted mouse-nest, within which she builds her nest; sometimes an old bird's nest is used for this purpose. In certain European species the queen, sometimes at least, constructs her nest entirely without making use of a nest of another animal. This she does by making use of moss or soft dead grass, which she combs together with her mandibles and legs; for this reason these species are often known as "carder-bees."

Many observers have studied the founding and development of colonies of bumblebees; among these is Sladen who has made very detailed studies of the species found in England. The following condensed summary is based on the statements of this author.

Having found a suitable nest the queen spends a good deal of time in it, the heat of her body gradually making its interior perfectly dry. She then gathers the finest and softest material she can find into a heap and in the center of this makes a cavity with an entrance at the side just large enough for her to pass in and out. In the center of the floor of this cavity she forms a lump of paste made of pollen moistened with honey.

Upon the top of this lump she builds with her jaws a circular wall of wax, and in the little cell so formed she lays her first batch of eggs, and seals it over with wax. The queen now sits on her eggs day and night to keep them warm, only leaving them to collect food when necessary. In order to maintain animation and heat through the night and in bad weather when food cannot be obtained, it is necessary for her to lay in a store of honey. She therefore sets to work to construct a large waxen pot to hold the honey. This pot is built in the entrance passage of the nest (Fig. 630).

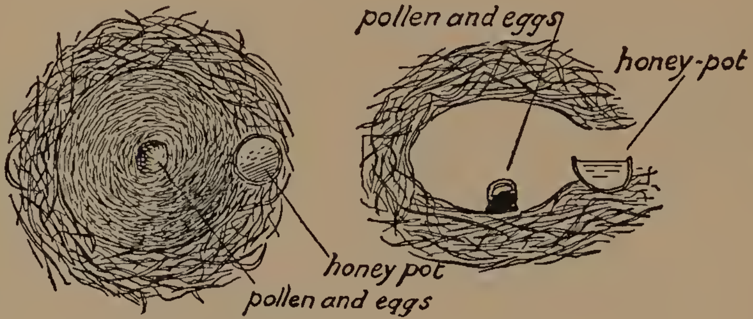
pollen and eggs
honey-pot
honey pot
pollen and eggs

FIG. 630. — Honey-pot. (From Sladen.)

The eggs hatch four days after they are laid. The larvæ devour the paste which forms their bed and also fresh food furnished by the queen. To feed the larvæ the queen makes a small hole with her mandibles in the skin of wax that covers them. While the larvæ remain small they are fed collectively, but when they grow large they are fed individually.

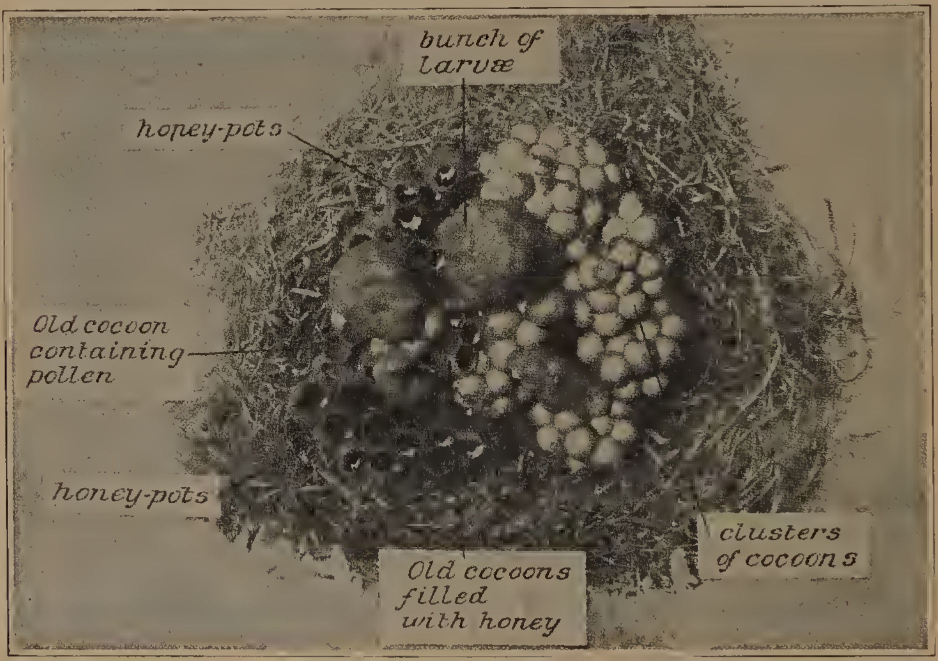
bunch of larvæ
honey-pots
Old cocoon containing pollen
honey-pots
Old cocoons filled with honey
clusters of cocoons

FIG. 631. — Nest in midsummer. (From Sladen.)

As the larvæ grow the queen adds wax to their covering, so that they remain hidden. When the larvæ are full-grown, each one spins around itself an oval cocoon, which is thin and papery but very tough. The queen now clears away most of the brown wax covering, revealing the cocoons, which are pale yellow. These first cocoons number from seven to sixteen, according to the species and the prolificness of the queen. These cocoons are incubated by the queen, who spends much time sitting on them, with her abdomen stretched to about double its usual length so that it will cover as many cocoons as possible.

The bees that are developed during the early part of the summer are all workers; these relieve the queen of all duties except laying the eggs. They feed the larvæ, construct honey-pots and special receptacles for pollen or store these substances in cocoons from which workers have emerged. Later in the summer males and queens are developed; and in the autumn the colony breaks up. A nest in midsummer is shown in Figure 631.

The bumblebees play a very important rôle in the fertilization of certain flowers, as those of red clover, in which the tubular corolla is so long that the nectar cannot be reached by bees with shorter tongues.

The parasitic bumblebees, *Psĭthyrus*. — To this genus belong those parasitic bees that infest the nests of bumblebees. They closely resemble bumblebees in appearance and in structure, except that, as in other parasitic bees, the females do not possess organs for collecting and carrying pollen. Although the females of *Psithyrus* are easily distinguished from those of *Bombus* by the absence of the pollen-baskets or corbiculæ in the former, the males of the two genera are very similar. In *Psithyrus* there is no worker caste.

Family APIDÆ

The Honey-bees

The family Apidæ, as restricted here, includes only a single genus, *Āpis*, of which only four species are known, and one of these is doubtfully distinct. In this country a single introduced species, the honey-bee, *Āpis mellĭfica*, is found. This species has been widely distributed over the world by man.

This family consists of social bees in which the hind tibiæ are without apical spurs; the workers are furnished with pollen-baskets or corbiculæ on the hind legs, but the queens are without functionally developed ones. Unlike the queen of the nest-building bumblebees the queen of the honey-bee is unable to found a colony or even to exist apart from workers of her own species.

The honey-bee was introduced into America more than three centuries ago, and escaping swarms have stocked our forests with it; for when free, swarms almost invariably build their nests in hollow trees. These nests include a variable number of vertical combs, which have cells on both sides, instead of a single series as is the case in the combs of our native social wasps. The cells of which the comb is composed are used both for storing the food of the colony and for rearing the brood.

The three castes of bees of which a colony is composed are easily distinguished. The workers are the well-known form that we see collecting pollen and nectar from flowers and entering and leaving the hive in large numbers. They constitute the greater part of the colony; an average strong colony will include from 35,000 to 50,000 workers. They are females in which the reproductive organs are imperfectly developed; they do not ordinarily lay eggs, and when they do the eggs develop only into males. The workers do not pair with males, consequently their eggs are unfertilized, and unfertilized eggs of the honey-bee produce only males. The workers are so-called because they perform all the labors of the colony. Young workers attend to the inside work of the hive; they take care of the young brood, and for this reason are termed nurse-bees, they build combs, and protect the entrance of the hive against robbers. The older workers go into the field to collect pollen, nectar and propolis.

The drones are larger than the workers, and are reared in larger cells. If honeycombs be examined, some sheets will be seen to be composed of larger cells than those of the more common type. It is in cells of this kind that the eggs are laid which are to develop into males. In shape the drones are broader and blunter than the workers. They are few in number and are only present in the hive during the early summer. After the swarming season is over, these gentlemen of leisure are driven out of the hive by the workers or are killed by them.

The queen is larger than a worker, and has a long pointed body. She is developed in a cell which differs greatly from the ordinary hexagonal cell of honeycomb. This cell is large, cylindrical, and extends vertically. In Figure 633 the beginnings of two queen cells are represented on the lower edge of the comb, and a completed cell extends over the face of the comb near the left side. From the lower end of this cell hangs a lid, which was cut away by the workers to allow the queen to emerge.

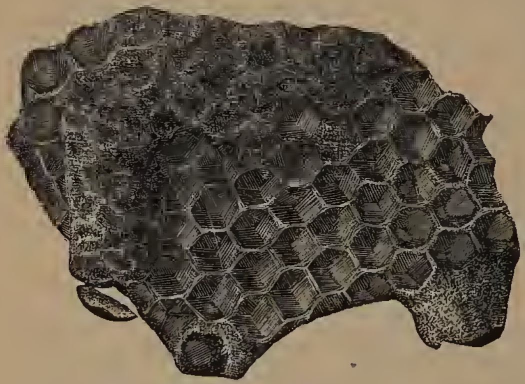
FIG. 632. — Comb of honey-bee with queen-cells.

The queen larva is fed with a substance called royal jelly. This is a substance which resembles blanc-mange in color and consistency. It is excreted from the mouth by the nurse-bees, and is very nutritious food. The origin of this food, whether it is a secretion from special glands of the nurse-bees, or is regurgitated from their stomachs is not at present known. During the first three days of the larval stage of worker bees they are also fed with royal jelly after which they are fed with honey and bee-bread.

It has been demonstrated that in the egg-state there is no difference between a worker and a queen. When the workers wish to develop a queen they tear down the partitions between three adjacent cells containing eggs that under ordinary conditions would develop into workers. Then they destroy two of the eggs, and build a queen-cell over the third. When the egg hatches they feed the larva with royal jelly, and it develops into a queen.

In early summer several queen-cells are provided in each colony. As soon as a queen is developed from one of these the old queen attempts to destroy her. But the young queen is guarded by the workers, and then the old queen with a goodly portion of her subjects swarms out, and they go to start a new colony.

The swarming of the honey-bee is essential to the continued existence of the species; for in social insects it is as necessary for the colonies to be multiplied as it is that there should be a reproduction of individuals. Otherwise, as the colonies were destroyed the species would become extinct. With the social wasps and with the bumblebees the old queen and the young ones remain together peacefully in the nest; but at the close of the season the nest is abandoned by all as an unfit place for passing the winter, and in the following spring each young queen founds a new colony. Thus there is a tendency towards a great multiplication of colonies. But with the honey-bee the habit of storing food for the winter, and the nature of the habitations render it possible for the colonies to exist indefinitely. And thus if the old and young queens remained together peacefully there would be no multiplication of colonies, and the species would surely die out in time. We see, therefore, that what appears to be merely jealousy on the part of the queen honey-bee is an instinct necessary to the continuance of the species.

The sting of a queen-bee is no ignoble weapon, but it is rarely used except against a rival queen. When several young queens mature at the same time there is a pitched battle for supremacy, and the last left living on the field becomes the head of the colony. One morning we found the lifeless bodies of fifteen young queens cast forth from a single hive — a monument to the powers of the surviving Amazon in triumphant possession within.

The materials used by bees are wax and prōpolis, which serve as materials for construction; and honey and bee-bread used for food.

The comb is made of wax, which is an excretion of the bees. When a colony needs wax, many of the workers gorge themselves with honey and then hang quietly in a curtain-like mass, the upper bees clinging to the roof of the hive, and the lower ones to the bees above them. After about twenty-four hours there appear on the lower surface of the abdomen of each bee little plates of wax that are forced out from openings between the ventral abdominal segments called wax-pockets. Other workers attend to this curtain and collect the wax as fast as it appears, and use it at once in constructing comb.

Prōpolis is a cement used for cementing up crevices, and is made of a resin which the bees collect from the buds of various trees, but especially of the poplar.

Honey is made from the nectar of flowers. The nectar is taken into the crop of the bee, and there changed into honey, and then regurgitated into the cells of the comb.

Bee-bread is made from the pollen of flowers, which the bees bring in on the plates fringed with hairs on the hind legs, the corbiculæ.

FAMILIES OF THE HYMENOPTERA NOT DISCUSSED

The order Hymenoptera contains a large number of families the members of which are rarely seen. The following list includes those families of which no account is given here. The student can find them discussed in "An Introduction to Entomology" by J. H. Comstock.

Xyelidæ
Xiphydriidæ
Argidæ
Aulacidæ
Gasteruptionidæ
Trigonalidæ
Stephanidæ
Ampulicidæ
Vanhorniidæ
Heloridæ
Roproniidæ
Platygasteridæ
Scelionidæ
Ceraphronidæ
Belytidæ
Evaniidæ
Embolemidæ
Cleptidæ
Bethylidæ
Anthoboscidæ
Thynnidæ
Sapygidæ
Rhopalosomidæ
Prosopidæ

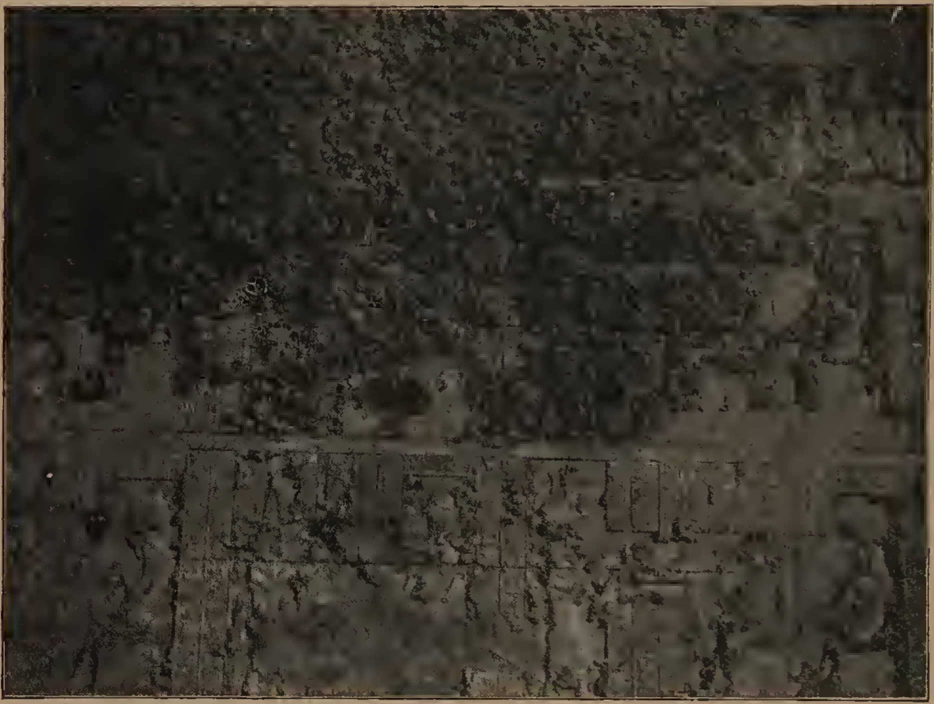

Fig. 633.—Nests of wall-bee on the Temple of Dendera.

A remarkable accumulation of the nests of an Old World species of mason-bee, known as the wall-bee, *Chalicoderma muraria*, was observed by the senior writer on the walls of the Temple of Dendera in Egypt. This temple, which was buried by drifting sands long ago has been excavated by modern archæologists; but the inscriptions on the walls are being rapidly buried again beneath a layer of the cement-like nests of the wall-bee (Fig. 633). This bee is a member of the family of leaf-cutter bees, Megachilidæ.

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